The Agricultural Journal of India

EDITED BY

The Agricultural Adviser to the Government of India

VOL. XIII

(1918)

PUBLISHED FOR

THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA

BY

THACKER, SPINK & CO., CALCUTTA

W. THACKER & CO., 2, CREED LANE, LONDON

PRINTED BY
THACKER, SPINK AND CO., CALCUTTA.

CONTENTS.

		PAGE
ORIGINAL ARTICLES.		
THE GANESHKHIND DAIRY HERD ...	*H. E. Lord Willingdon, G.C.I.E.* ...	1
WHEAT VARIETY TRIALS IN THE PUNJAB ...	*W. Roberts, B.Sc.* ...	10
JOHNE'S DISEASE	*A. Leslie Sheather, B.Sc., M.R.C.V.S.*	23
PRESENT POSITION AND FUTURE PROSPECTS OF THE NATURAL INDIGO INDUSTRY ...	*W. A. Davis, B.Sc., A.C.G.I.* ...	32
EXPERIMENTS IN STEAM-PLOUGHING ...	*Sirdar Jogendra Singh* ...	47
THE CO-OPERATIVE DAIRY AT TELINKHERI IN ITS RELATION TO DAIRYING IN THE CENTRAL PROVINCES	*D. Clouston, M.A., B.Sc.* ...	54
WHEAT IN THE NORTH-WEST FRONTIER PROVINCE	*W. Robertson Brown*	65
AGRICULTURAL BANKING IN THE DELTA OF BURMA	*Lawrence Dawson* ...	71
THE DAILY VARIATION IN THE COMPOSITION OF MILK	*D. Ananda Rao, B.Sc.* ...	82
SELECTED ARTICLES.		
THE EFFECT OF ONE PLANT ON ANOTHER ...	*Spencer Pickering* ...	86
THE TREATMENT OF FUNGOID DISEASES ON ESTATES	*R. D. Anstead, M.A.*	95
COTTON-GROWING RESOURCES OF THE BRITISH EMPIRE	*J. Arthur Hutton* ...	105
THE WORLD'S COTTON SHORTAGE ...	*Prof. John A. Todd*	110
CO-OPERATIVE SOCIETIES FOR THE SALE OF COTTON IN THE SOUTHERN MARATHA COUNTRY	*The Hon. Mr. G. F. Keatinge, C.I.E., I.C.S.* ...	121

		Page
Some Recollections and Reflections ...	*H. R. Crosthwaite* ...	131
Agricultural Progress in India ...	*A. C. Chatterjee, I.C.S.* ...	139
The Action of Copper Arsenate and Arsenious Acid on Sugarcane Roots ...	... ...	145
The Importance of Soil Ventilation ...	... ...	148
Horse-Breeding in India	... ...	152
Rural Science, including School-Gardening	*R. N. Sheridan* ...	[illegible]5
An Experiment in Rural Bias in a Secondary School	... ...	162

NOTES.

Indian Cotton Committee	164
American Cotton in the Punjab	167
Willingdon Dairy Herd Sale	167
Results of Berseem Cultivation on some Dairy Farms ...	168
Peculiar Mineral Requirements of Crops	169
The Five most Promising Breeds of Milch Cattle and Two Breeds of Buffalos in India	170
Electric Farming and some Results	171
Cotton-Seed Oil Industry	173
Cotton Research	174
Cotton Cultivation in China	175
Services Rendered by Birds to Agriculture	177
A Model Village Co-operative Society	178
Important Industrial Project	181
Malaria and Agriculture	182

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.	**183**

REVIEWS.

Note on Cattle in the Bombay Presidency	189
The Fruit Garden in India (in English and Urdu) ...	189

CORRESPONDENCE.

Not Enough to Eat?	191
NEW BOOKS ON AGRICULTURE AND ALLIED SUBJECTS ...	**194**

CONTENTS.

PAGE

ORIGINAL ARTICLES.

RAINFALL, IRRIGATION AND THE SUBSOIL WATER LEVEL OF THE GANGETIC PLAIN IN THE UNITED PROVINCES OF AGRA AND OUDH ..	*C. H. Hutton, M.I.C.E.* ..	197
THE PRESENT POSITION AND FUTURE PROSPECTS OF THE NATURAL INDIGO INDUSTRY ..	*W. A. Davis, B.Sc., A.C.G.I.* ..	206
THE CONSOLIDATION OF AGRICULTURAL HOLDINGS IN THE UNITED PROVINCES.. ..	*Prof. H. Stanley Jevons, M.A., F.S.S.*	222
THE TENTH MEETING OF THE BOARD OF AGRICULTURE IN INDIA ..		231
IN MEMORIAM: THE LATE LIEUT. E. J. WOODHOUSE, M.A., F.L.S. ..		242
TESTING NEW CANE SEEDLINGS IN NORTH INDIA	*C. A. Barber, Sc.D., F.L.S.* ..	243
THE TREND OF INDIAN AGRICULTURAL EXPORTS	*A. C. Dobbs* ..	249
AN ACCOUNT OF SOME EXPERIMENTS IN LUCERNE CULTIVATION AT SAHARANPUR REMOUNT DEPÔT	*Major J. Bruce, A.R.D.* ..	254
THE SPREAD OF CO-OPERATION IN THE PUNJAB ..	*C. F. Strickland, B.A., I.C.S.* ..	260
SOME OBSERVATIONS ON AGRICULTURAL WORK IN EGYPT, AMERICA, AND JAPAN: II. AMERICA	*W. Roberts, B.Sc.* ..	272
EXPERIMENTS WITH NIGHT-SOIL AS MANURE ..	*P. C. Patil, L.Ag.* ..	281

SELECTED ARTICLES.

THE WORLD'S COTTON SHORTAGE ..	*Prof. John A. Todd*	287
FACTORS IN AGRICULTURAL PROGRESS ..	*The Hon. Mr. G. F. Keatinge, C.I.E., I.C.S.* ..	298

		Page
Development of Banking and Thrift in India	*A. C. Chatterjee, I.C.S.* ..	305
Sale and Loan of Agricultural Implements	*The Hon. Mr. H. R. C. Hailey, C.I.E., I.C.S.* ..	319
India's Greatest Industry: Scope for Agricultural Machinery	*D. Clouston, M.A., B.Sc.* ..	325
A Few Simple Tests for use of Dairy Farmers, Dairymen, and Students ..	*R. Osborne, N.D.D. (I)* ..	333

NOTES.

Acacia modesta, A Hedge Plant	347
Bee-keeping	348
The Food Value of the Groundnut	351
A New Cane Disease	355
The Nitrate Position	356
Physiological Effect on Growth and Reproduction of Rations balanced from restricted Sources	358
Prohibition, regulation and restriction of Import into British India of certain Plants and Seeds	359

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC. 363

REVIEWS.

Plant Types for College Students	366
The Agricultural Problems in India	367
All about the Mango (In Marathi)	367

CORRESPONDENCE.

Tying up the Young Stock	368
Density of Cotton Bales in India	368
Mr. Jordan on the Problem of Sugar Manufacture in India ..	369
Reply to Mr. Jordan's Criticism	374
NEW BOOKS ON AGRICULTURE AND ALLIED SUBJECTS ...	377
List of Agricultural Publications in India from 1st August 1917, to 31st January 1918	after p. 380

CONTENTS.

ORIGINAL ARTICLES.

		Page
The True Sphere of Central Co-operative Banks	*R. B. Ewbank, I.C.S.*	381
The Early History of Cotton in Bombay ..	*J. Mackenna, C.I.E., I.C.S.* ..	389
The Present Condition of Lac Cultivation in the Plains of India	*C. S. Misra, B.A.*	405
Recent Investigations on Soil-Aeration Part I. With Special Reference to Agriculture	*A. Howard, C.I.E., M.A., A.R.C.S., F.L.S.* ..	416
Part II. With Special Reference to Forestry	*R. S. Hole, F.C.H., F.L.S., F.E.S.*	430
Present Position and Future Prospects of the Natural Indigo Industry ..	*W. A. Davis, B.Sc., A.C.G.I.* ..	441
Rainfall, Irrigation and the Subsoil Water Level of the Gangetic Plain in the United Provinces of Agra and Oudh ..	*C. H. Hutton, M.I.C.E.* ..	460
Land and Labour in a Deccan Village: A Review	*The Hon'ble Mr. G. F. Keatinge, C.I.E., I.C.S.* ..	471
Veterinary Research: Some Recent Contributions	.. ..	479

	Page
SELECTED ARTICLES.	
Food Production : Considerable Increase Possible	495
Vegetable Fibres	500
Nitrogen Fixation	505
A Textile Substitute : Experiment with Nettle Fibre ..	522
The Protection of Wheat from Weevils	527
The Importance of Mold Action in Soils	529
Notes on Motor Cultivation	537
NOTES.	
Origin of the Uba Cane	544
Ten Years of Agriculture throughout the World	546
Water Hyacinth	549
The Cotton Seed Industry	549
Statistics of the Provincial Civil Veterinary Departments ..	551
Spike Disease in Sandalwood	552
Silk Culture in India	553
Indigo Cess Act	555
Levy of a Cess on Indigo exported from Travancore ..	556
Rules for Disinfection of Plants	556
Regulation of Import of Plants by Post	557
Importation of Flax and Berseem Seeds into British India by Sea	557
PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.	**558**
REVIEWS.	
A Handbook of Nature Study	565
The High Price of Sugar and How to Reduce it	566
A Survey of the Madras Dairy Trade	568
Establishment and Management of the Dairy Farm ..	570
Bulletin on the Cultivation of Areca Palm in Mysore ..	572
Mysore Agricultural Calendar for 1918	573
Journal of the Indian Economic Society	573
Anatomy of Silkworm and Moth	575
CORRESPONDENCE.	
Handling Young Stock	576
Density of Indian Cotton Bales	576
Problem of Sugar Manufacture in India	577
NEW BOOKS ON AGRICULTURE AND ALLIED SUBJECTS ...	**578**

CONTENTS.

(Vol. XIII, Part IV.)

		Page
ORIGINAL ARTICLES.		
The Organization of Agricultural Research in India	*H. M. Leake, M.A., F.L.S.* ..	583
The Oil Engine and its Application to Indian Agriculture..	*W. M. Schutte, A.M.I. Mech. E., M.R.A.S.E.*	608
The Sun-drying of Vegetables	*G. L. C. Howard, M.A.* ..	616
Beginnings in Insect Physiology and their Economic Significance	*S. K. Sen, B.Sc.* ..	620
The Use of Surplus Milk in a Small Dairy: Cheese-Making	*R. G. Allan, M.A., and J. V. Takle, L.Ag., N.D.D.(I.)*	628
Common Contagious Cattle Diseases and Methods of Dealing with Them ..	*R. Branford, M.R.C.V.S.* ..	639
Irrigation in Sind	*T. F. Main, B. Sc.*..	653
Manuring of *Hevea brasiliensis*	*R. D. Anstead, M.A.*	660
Fungi and Disease in Plants: A Review..	*G. A. Gammie, F.L.S.* ..	666
The Spread of Co-operation in the Punjab. II.	*C. F. Strickland, B.A., I.C.S.* ..	671
SELECTED ARTICLES.		
Afforestation in the United Provinces		685
Selecting Sugarcane before Planting: Some Demonstrative Experiments		695

PAGE

SCIENTIFIC PROGRESS IN SUGAR CULTIVATION AND MANUFACTURE IN JAVA DURING THE LAST THREE YEARS 701
MOTOR TRACTORS: UTILITY FOR TILLAGE PURPOSES 710
NOTE ON THE BALING OF SHAFTAL AND LUCERNE HAY FOR ARMY TRANSPORT 717

NOTES.

THE EFFECT ON GERMINATION OF COTTON SEED OF PASSING THE *Kapas* THROUGH THE "OPENER" 719
COTTON RESEARCH 721
PROHIBITION OF THE IMPORTATION OF COTTON PLANTS, UNGINNED COTTON AND COTTON SEED INTO FRENCH COLONIES 723
SNAPSHOTS TAKEN DURING A MISSION TO MESOPOTAMIA 725
FACILITIES FOR TRANSPORT BY RAIL OF IMPROVED VARIETIES OF SEED FOR SOWING 725
SOME PROBLEMS OF WHEAT STORAGE 726
THE ORIGIN OF THE UBA CANE 727
A NEW PROCESS IN HAWAIIAN SUGAR INDUSTRY 728
MANUFACTURE OF NATALITE AND OTHER CANE BY-PRODUCTS .. 729
A NEW USE FOR SUGAR IN THE CURING OF RUBBER 731
GERMAN PHOSPHATE "SUBSTITUTES" 731
NATURAL OR SPONTANEOUS COAGULATION OF THE LATEX IN THE PRODUCTION OF RUBBER 734
EFFECT OF LIGHT ON HEALING OF TREE WOUNDS 734
MANUFACTURE OF POTATO STARCH IN NORWAY 735
PRECAUTIONS FOR PREVENTING THE DANGER OF INFECTION BY ANTHRAX IN THE MANIPULATION OF WOOL, GOAT-HAIR AND CAMEL-HAIR 736

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC. 737

REVIEWS.

PRUSSIC ACID IN BURMA BEANS 741
THE ZEMINDAR HITKARI OR THE ZEMINDAR'S FRIEND 742
BULLETIN ON THE UTILIZATION OF INFERIOR GRASS HERBAGE .. 743
REPORT OF THE PROCEEDINGS OF THE ALL INDIA COW CONFERENCE, CALCUTTA 744

CONTENTS.

		Page
Indian Agricultural Development ...	*Leslie C. Coleman, M.A., Ph.D.* ...	1
Immunity and Disease in Plants ...	*E. J. Butler, M.B., F.L.S.* ...	10
The Economic Aspect of Indian Silviculture	*Edward Marsden* ...	29
Some Methods suitable for the Study of Root Development	*Albert Howard, C.I.E., M.A., and Gabrielle L. C. Howard, M.A.* .	36
Timber Supplies in India	*R. S. Pearson, F.L.S.*	40
Oxidases: With special reference to their Presence and Function in the Sugarcane	*Ramji Narain, M.Sc.*	47
Rhizoctonia in Jute: The inhibiting effect of Potash Manuring	*R. S. Finlow, B.Sc., F.I.C.* ..	65
The Spraying of Tea in North-East India	*A. C. Tunstall, B.Sc*	73
Some Factors affecting the Efficiency in the Use of Canal Water	*W. Roberts, B.Sc., and O. T. Faulkner, B.A.* ...	81
The Physical Texture of Soils in its relation to Crop Production ...	*D. Clouston, M.A., B.Sc., and A. R. Padmanabha Aiyer, B.A.* ...	89
Forest Grazing and the Nellore "Kancha" System	*Cecil E. C. Fischer*	95
Some Observations about the Soils of the North-East Indian Tea Districts ...	*G. D. Hope, Ph.D., B.Sc., F.C.S.* ...	102
Forest Insect Conditions in India ...	*C. F. C. Beeson, M.A.* ...	114
Experiments in planting Sugarcane Sets with a Single Eye-Bud and Pot Experiments with other Seeds placed in different positions while planting ...	*M. L. Kulkarni*	125

LIST OF ILLUSTRATIONS.

Photo of H. E. Lord Willingdon, G.C.I.E., Governor of Bombay ... Frontispiece

			Facing Page
Plate	I.	Ganeshkhind Dairy Herd...	4
		Fig. 1. The Herd—Young Stock.	
		Fig. 2. Milch Cows and Bull.	
		Fig. 3. Farm Buildings—Silo and Dairy.	
Plate	II.	Fig. 1. Cow Byre	4
		Fig. 2. Silo, Cow Byre, and Dutch Barn.	
Plate	III.	Sunder and Krishni	8
Plate	IV.	Radhi and Lali	8
Plate	V.	Mor and Mari	8
Plate	VI.	Luxumi and Shevanti	8
Plate	VII.	Piri and Yeshi	8
Plate	VIII.	Tansa and Stud Bull	8
Plate	IX.	Johne's Disease	26
		Fig. 1. A portion of the small intestine ($\frac{7}{10}$ natural size), showing the wrinkled appearance of the mucous membrane.	
		Fig. 2. Section through the mucous membrane of the small intestine, showing the intact surface epithelium (A) and the infiltration of plasma or epithelioid cells between the glands of Lieberkühn. (B). (× 80.)	
		Fig. 3. Section through the mucous membrane of the small intestine, showing the infiltration of plasma or epithelioid cells and a part of two of the glands of Lieberkühn. (× 500.)	
Plate	X.	Johne's Disease	27
		Fig. 1. Section through the mucous membrane of the small intestine, showing the thickening and distortion of the villi produced by the infiltration with plasma cells. (× 80.)	

Facing Page

tealP X. Fig. 2. Section through the mucous membrane of the small intestine, showing large masses of bacilli (A) and small groups in which the individual organisms can be seen (B). (×400.)

Fig. 3. Section of mesenteric gland, showing a giant cell (A). (×500.)

Fig. 4. A group of bacilli (A) in a preparation made from the mucous membrane of the intestine. (×1000.)

Plate XI. Fig. 1. Typical short-horned buffalo ... 55

Fig. 2. Typical long-horned buffalo.

Fig. 3. Sirguja buffalo.

Plate XII. Fig. 1. Ayrshire-Gaolao Cross 58

Fig. 2. Montgomery-Gaolao Cross.

Plate XIII. Fig. 1. Dairy cattle having their drink and bath in Telinkheri Tank 60

Fig. 2. *Gowlies* going for delivery of milk bottles and vessels.

Plate XIV. Alternate lines of sugar-beet and Federation wheat... 70

Note.—There are also three charts, *viz.*, one illustrating the article of Mr. W. A Davis on Present Position and Future Prospects of the Natural Indigo Industry, and two illustrating Mr. Ananda Rao's paper on Daily Variation in the Composition of Milk.

LIST OF ILLUSTRATIONS.

Photo. of Mr. J. Mollison, C.S.I., M.R.A.C.			.. ..	Frontispiece
				Facing Page
Plate	XV.	Fig. 1.	Arrival of indigo at the vats	214
		Fig. 2.	Loading the vats	
Plate	XVI.	Fig. 1.	The vat loaded with plant and filled with water	216
		Fig. 2.	The beating vats	
Plate	XVII.	Fig. 1.	Filtering and Pressing indigo	218
		Fig. 2.	Filter and Press House	
Plate	XVIII.		The late Lieut. E. J. Woodhouse	242
Plate	XIX.		*Sorghum* under Night-soil manure	282
Plate	XX.		Typical hedges of *Acacia modesta*	348
Plate	XXI.		The late Mr. C. W. Mason	364

PRINTED BY
THACKER, SPINK AND CO., CALCUTTA.

LIST OF ILLUSTRATIONS.

Photo of Sir Frank George Sly, K.C.S.I., I.C.S.		..	Frontispiece.
			Facing Page
Plate	XXII.	The Indian Cotton Committee	389
Plate	XXIII.	*Tachardia lacca*	405
Plate	XXIV.	Showing healthy growth of *sal* seedlings in *sal* forest loam in uncorked pots	430
Plate	XXV.	Figs. 1 and 2. Showing the unhealthy effect of covering the surface soil with a layer of dead *sal* leaves, the drainage holes at the base of the pots being kept open	430
Plate	XXVI.	Fig. 1. Showing no injurious effect of dead leaves on *sal* seedlings growing in sand instead of forest loam. Fig. 2. Showing the results of bad soil-aeration in pots the basal drainage holes of which have been corked	432
Plate	XXVII.	Fig. 1. Showing the two-years-old seedlings surviving in a forest shade plot. Fig. 2. Showing the vigorous two-years-old seedlings in a clear-felled forest plot	434
Plate	XXVIII.	Fig. 1. Showing vigorous development of healthy roots near the apex of *sal* seedlings growing in water-culture solution for four months. Fig. 2. Showing the root-systems of two *sal* seedlings grown in water-culture for 19 days, one grown in aerated solution, the other gassed for two minutes daily	436
Plate	XXIX.	Figs. 1 and 2. Showing the root growth of *sal* seedlings of the same age in porous and dense loam respectively	438

Note. There is also a map showing the distribution of lac cultivation in India, opposite page 414.

PRINTED BY
THACKER, SPINK AND CO., CALCUTTA.

PAGE

CORRESPONDENCE.

THE PROBLEM OF SUGAR MANUFACTURE IN INDIA 747

(1) Mr. A. E. Jordan's comments on Mr. Wynne Sayer's letter 747
(2) Mr. Jordan's letter to the *Madras Mail* on "Sugar Development in Mysore" 751
(3) Mr. Wynne Sayer's Rejoinder 754

MOTOR CULTIVATION 759

NEW BOOKS ON AGRICULTURE AND ALLIED SUBJECTS ... 761

LIST OF AGRICULTURAL PUBLICATIONS IN INDIA FROM 1ST FEBRUARY TO 31ST JULY, 1918 .. .. after p. 764

LIST OF ILLUSTRATIONS.

Photo. of Mr. Bernard Coventry, C.I.E. Frontispiece

Facing page

Plate XXX. Snapshots from Mesopotamia: Fig. 1. The Holy Shrine of Kerbala. Fig. 2. A typical river village. Fig. 3. A group of "Fellaheen." Fig. 4. Iraq buffaloes. Fig. 5. An old canal bank. Fig. 6. Iraq sheep 724

Plate XXXI. Snapshots from Mesopotamia: Fig. 1. Canal and gardens. Fig. 2. A Remount Depôt. Fig. 3. Berseem. Fig. 4. Wheat coming into ear. Fig. 5. Arab method of planting seedling tomatoes, etc., in shelter. Fig. 6. Typical land, uncultivated, but showing marks of old irrigation canals ... 725

Plate XXXII. Snapshots from Mesopotamia. Fig. 1. Arab plough and cattle. Fig. 2. Arab plough showing detachable share. Fig. 3. Long-handed spade. Fig. 4. Arab "Arabiyah." Fig. 5. Water lift. Fig. 6. Water lift 726

Besides these there are a plate of curves opposite page 623 and a map on page 640

PRINTED BY
THACKER, SPINK AND CO., CALCUTTA.

LIST OF ILLUSTRATIONS.

Photo of His Honour Sir Michael Francis O'Dwyer, G.C.I.E., K.C.S.I. .. .. *Frontispiece*

Facing Page

Plate I. Teak plantation in Burma, three years old, formed by sowing teak seed in combination with the cultivation of a catch-crop 29

Plate II. Teak plantation at Nilambur, Madras, age 65 years, nearly mature 30

Plate III. Fig. 1. Chir pine forest, closed to grazing, showing natural regeneration 32

Fig. 2. Chir pine forest, open to grazing, showing complete absence of natural seedlings.

Plate IV. Good natural regeneration of chir pine, showing seed-bearers being tapped for resin 33

Plate V. Plantation of *Bucklandia populnea*, 38 years old .. 34

Plate VI. Fig. 1. Sugarcane on *bhata* 91

Fig. 2. Groundnut grown on (*a*) *bhata*, (*b*) black soil.

Fig. 3. Indigo on *bhata*.

Fig. 4. Indigo on black soil.

Plate VII. Fig. 1. Cotton on *bhata* 92

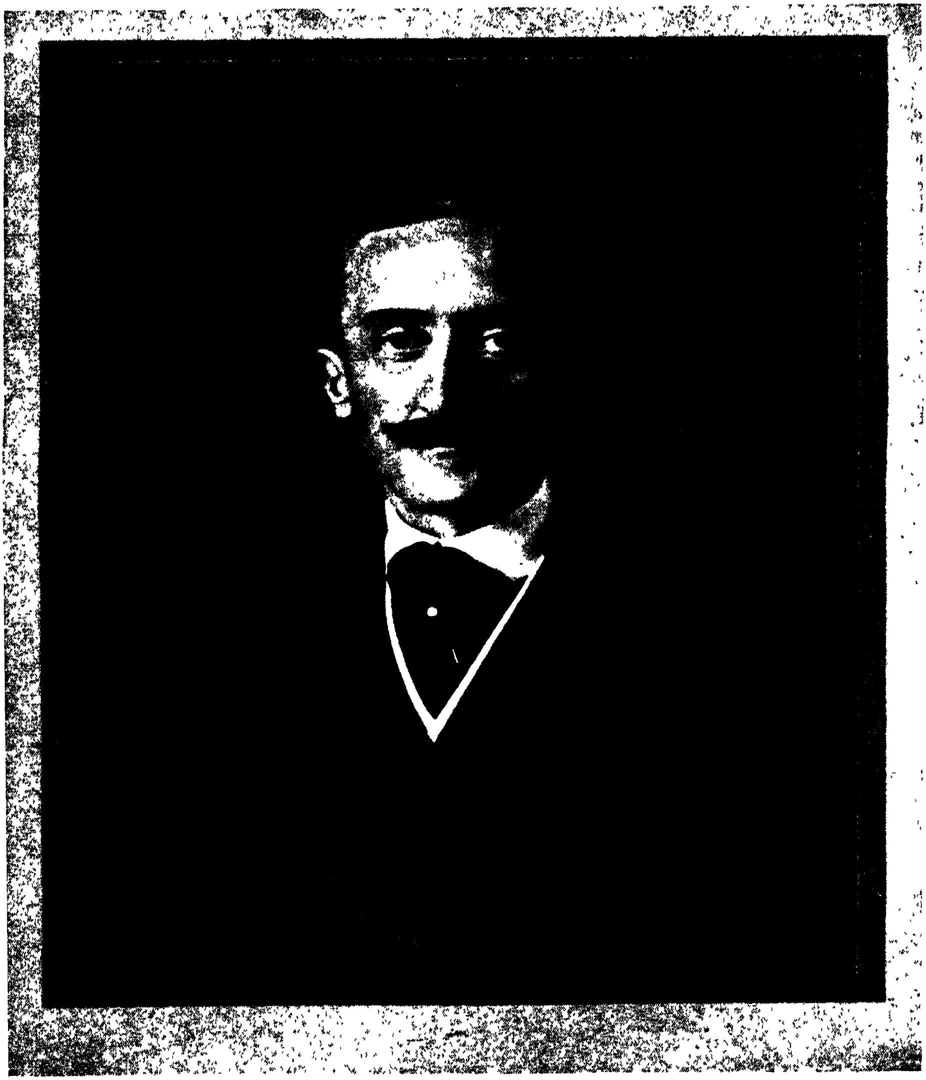
Fig. 2. *Juar* on black soil.

Fig. 3. *Juar* on *bhata*.

Plate VIII. Fig. 1. Side view of the sugarcane rows grown with single eye-bud sets 126

Fig. 2. Front view of the sugarcane rows grown with single eye-bud sets.

Note.—There are also four diagrams illustrating Dr. G D. Hope's paper on "Some observations about the soils of the North-East Indian Tea Districts."



HIS EXCELLENCY LORD WILLINGDON, G.C.I.E
GOVERNOR OF BOMBAY.

Original Articles.

THE GANESHKHIND DAIRY HERD.

BY

H. E. LORD WILLINGDON, G.C.I.E.,

Governor of Bombay.

In venturing to write a short description of my home farm at Ganeshkhind, I do so in the hope that it may stimulate greater interest in a branch of our agricultural industry, which, if properly developed, may prove to be an important addition to the activities and profits of those who are engaged in the occupation of farming.

In comparing the agricultural conditions of England with those of India we necessarily observe many disparities, of which perhaps the chief is the prevalence in India of peasant holdings and in England of considerable or large estates. There are, however, many exceptions to the normal state of affairs in both countries, and there are many parts of India where large holdings predominate. In such cases the main point of difference between our two countries lies in this fact, that the landowner in England is in most cases a farmer himself who has his own home farm, breeds his own stock, and cultivates some of his own land, and thus acquires a practical knowledge of agricultural life and takes a keen and sympathetic interest in the welfare of his tenants and labourers. In this country, on the other hand, the great landowner, who is himself a practical agriculturist on a large scale, is unfortunately rare. But an

important feature of similarity for our present purpose in both countries is the existence of various fine breeds of cattle from which the breeder can select that best suited for his locality and purposes.

It is, I am convinced, largely the fact that the landowner has in England been a keen breeder of stock himself, which has produced the fine herds of cattle in that country, and which has encouraged the numerous agricultural shows, where we often find our King-Emperor, great landowners, and tenant farmers all competing in friendly rivalry, and the tenant farmer not uncommonly proving successful over his Sovereign and his other august rivals. Is it too much to hope that a similar development in cattle-breeding may take place in this country ? That in future years we may find fine stud herds of the various breeds in India ? And that landowners and farmers may add interest to their own lives and profit in their occupation by producing good stock true to type throughout the country ? I am glad to be able to state that already in this Presidency two ruling princes are establishing stud herds in their States, His Highness the Raja of Rajpipla having started a herd of Kankreji cattle at Nandod, and His Highness the Nawab of Junagadh a herd of Gir cattle at Junagadh, while the Chiefs of Sangli, Jamkhandi, and Aundh are directing attention to the Krishna Valley and Khillari breeds—examples which I trust may be followed by many more princes, chiefs, and landowners.

I do not wish it to be thought that I am of opinion that there are no good cattle bred in this country. On the contrary, in this Presidency alone there are several fine breeds, notably the Kankreji in the north, the Krishna Valley and Khillari in the south, the Gir cattle from Kathiawar, and the Karachi cattle from Sind. It is the very fact that at various agricultural shows I have seen magnificent animals that makes me urge a further and more organized development of this industry. Let me state the objections which I often hear raised to the encouragement of dairy cattle. It is said that the farmer in India cares little for milk production but breeds entirely to produce good draught stock. My answer to that is that a good milking cow will produce just as good a draught bullock

as a bad milker, that milk is becoming more urgently necessary for the inhabitants of our big cities, that a good milker costs no more to keep than a bad milker and therefore it must be a more profitable animal for the farmer. Again, it is objected that the buffalo is *par excellence* the milking animal of India, as it is claimed that its milk contains more butter fat than that of the ordinary cow, which is essential for the production of *ghee.* · That may be true at the moment, but I am inclined to think that, with careful selection and breeding from the best milking strains and good management, dairy cattle may be produced in this country economically as paying an animal as the buffalo. Of this I am certain that no lover of cattle would prefer to keep a herd of buffalos, if he can secure equally good results from the many beautiful animals I have seen since I have lived in India. It is further objected that it is very difficult in some localities to find the men to look after the cattle, and that the conditions of the climate render the dangers of starvation to valuable stock constantly a matter of extreme anxiety. To the first of these objections I would reply that everything must have a beginning, and I see no reason to suppose that it is impossible to raise up a class of men who could take a keen interest in the care of cattle and become as efficient in this country as is the case in other countries. To the second I would say that the fears of famine are so much lessened by the conservation of fodder, by the development of railways to carry it to any stricken area, and by the constant extension of all forms of irrigation, that this peril is becoming less and less every year. That there are difficulties I freely admit, but difficulties are made to be overcome. The main essential to success lies in the interest and supervision of the owner himself, without which little will be achieved.

I approach this question with all diffidence, for I have only the experience of four years in India, though I can claim to have had cattle for many years in England ; but I think it is true to say that it has been a practical experience which few individuals have attempted, and which confirms me in my view that there should be a great future for cattle-breeding in this country. Let me, therefore, express the hope that the example of my humble effort in this

direction may be followed by others, and that our best breeds of cattle will be bred and perpetuated on the most scientific lines in future years.

May I, in conclusion, venture to give a few hints and suggestions to those who may be encouraged after reading this paper to start a dairy farm themselves ?

1. The owner should personally supervise and pay constant visits to the farm. He should not expect results for the first three years, until the young stock he breeds are coming into profit. He will then be able to add to his herd the young heifers which he thinks are likely to prove the best milkers, and sell off the surplus stock by auction or otherwise, which will go to improve the cattle in his neighbourhood. He should keep a register of each cow in his herd, showing the calves she produces year by year and the amount of milk she gives through the year. I would further suggest that in starting stud herds every owner should, as we often do in England, name each animal by the name of the State or locality where it is bred, *e.g.*, "Marie of Junagadh," "Rose of Rajpipla"; by this means it is always possible to trace the stock of any herd, and buyers will always know from what foundation stock they come.

2. Give the cattle lots of exercise, and let them lead as far as possible their natural lives. Never tie young stock up; let them run in a paddock as soon as they can, and when shut up, put them in a shed with an open yard to run out into.

3. Give the cattle lots of food. No animal can prosper unless it is properly fed, but with food and careful tending the cows will become more regular in their breeding and produce more milk, and young stock will come to maturity earlier if they are well fed and cared for in their early years.

4. Keep the farm and stables absolutely clean, and give the cows ample bedding when they are in the byre.

These are among the chief essentials which are necessary to the successful management of a farm. I have endeavoured to carry them out on my own, and I think my facts and figures will prove with not unsatisfactory results.

Fig 1 THE HERD - YOUNG STOCK.

Fig 2 MILCH COWS AND BULL

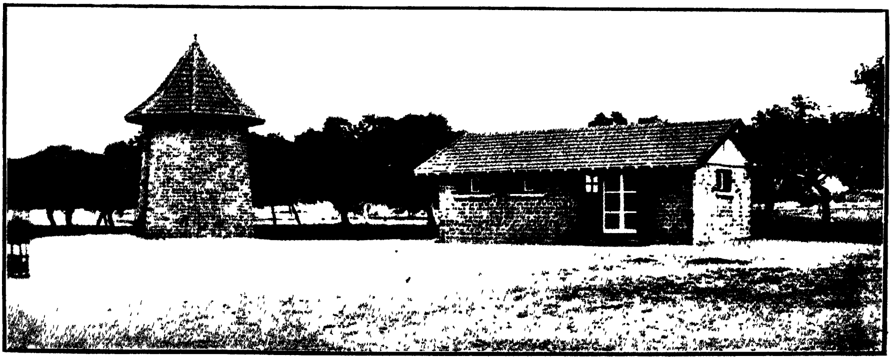


Fig. 3. FARM BUILDINGS — SILO AND DAIRY.

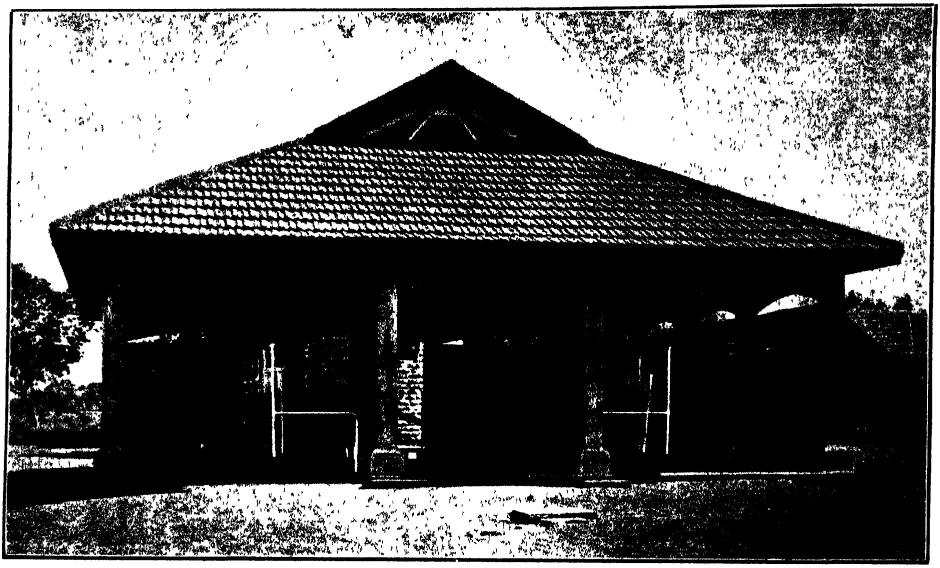


Fig. 1. COW BYRE.

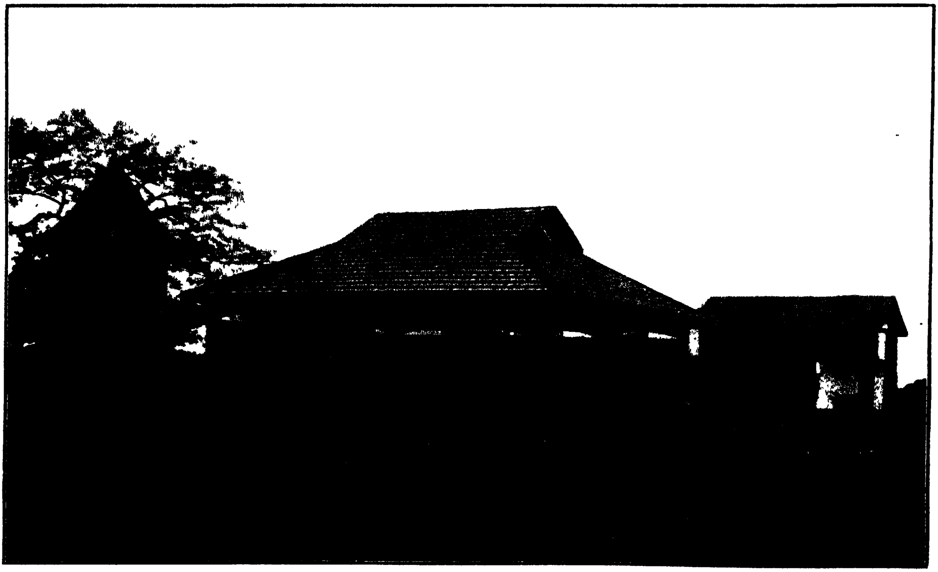


Fig. 2. SILO, COW BYRE, AND DUTCH BARN.

Government House Dairy and Farm.

Ganeshkhind Dairy and Farm were started in October 1913. They are situated in the Park at Ganeshkhind about a quarter of a mile from Government House.

Buildings. The farm buildings consist of a cow byre containing 16 stalls built on the latest American system, a small dairy, silo, Dutch barn, sheds for young stock, and a calving shed. The buildings are all made of stone, and the cow byre is stone-floored throughout, thus enabling the herdsmen to keep the byre clean, which is the first important step if cattle are to be kept healthy and well. Each stall has a separate feeding trough with cold water laid on, thus making it possible for each trough to be kept clean after each meal. The dairy has a tiled floor and glazed tile walls, and is about twenty feet by ten, and consists of two small rooms, one containing the churn and butter-maker and the other a milk-separator.

Silo. This is a stone building in which green fodder is stored and made into ensilage, which gives an excellent food for the cattle when fodder is scarce and expensive.

Dutch Barn. This is a stone building, bricked up on three sides, with one side left open, and is used for stacking any crops that have been cut until they may be required, and also for housing farm implements.

Acreage. The arable land consists of about 26 acres in which the principal crop is lucerne which is cut green for the use of the stable horses. The surplus is sold and finds a ready market. Maize, *jowar* (*Andropogon Sorghum*), and other fodder crops are also grown for the cattle.

Stock. The farm started with eight cows, eight heifers, and one bull, and the breed is pure Karachi, or as it is sometimes, though less accurately, called Sindhi. To-day the stock consists of 53 head including 16 cows, 1 stud bull, and the remainder young stock. At an auction sale in September 1916, the sum of Rs. 3,200 was obtained for 16 surplus young stock, or an average of Rs. 200 per head.

Fodder. The cattle have good grazing during some months of the year in the park of 400 acres. They are turned out morning and evening to graze, and during the day the cows are tied up in the

cow byre. Besides what they can pick up in this way, every cow has a daily ration of *chooni*, bran, cotton-seed, and salt.

Milk. The supply of milk has been yearly increasing, and the amount of milk received from April 1916 to March 1917 totals 37,309 lb., or an average of a little over 3,100 lb. per month.

Milk received monthly from April 1916 *to March* 1917.

Month	Quantity in lb.	Average number of cows in milk during the month
1916		
April	2,868	10
May	3,902	11
June	2,771	9
July	2,985	10
August ...	2,641	9
September	3,702	10
October .	3,781	11
November ...	3,337	11
December ...	3,231	11
1917		
January	2,815	9
February	2,377	8
March	2,899	8
	37,309	

Accounts as per statement below show for 1915-16 a profit of Rs. 376-1-4 and for 1916-17 Rs. 1,168-12-8 after allowing for interest on capital outlay on buildings, Rs. 12,000, and purchase of stock, Rs. 3,000, at 5 per cent.

Government House Dairy and Farm.

Statement of Accounts from 1st *April* 1915 *to* 31st *March* 1916.

Cr.

	Rs.	A.	P.	Rs.	A.	P.
By Income of milk, etc.	5,201	2	0			
" " lucerne grass sold ...	279	2	10			
" " *kadbi* sold	66	11	6			
" Value of live stock sold	350	0	0			
" " firewood sold	48	0	0	5,945	0	4
" Stock of lucerne grass, *kadbi*, and hay in hand on 31st March 1916, debited to next account ...				1,620	0	0
Total ...				7,565	0	4

Dr.

	Rs.	A.	P.	Rs.	A.	P.
To Stock of lucerne, *kadbi*, and hay, etc., brought over from last account ..	nil			nil		
" Establishment and labour ..	1,669	15	0			
" Ploughing expenses	203	0	0			
" Hay making do. ..	29	0	0			
" Value of seeds purchased	259	8	0			
" " fodder do. ...	3,628	6	3			
" Railway freight, etc., and allowances ..	320	15	6			
" Value of new dairy appliances purchased, and repairs, etc.	314	15	0			
" Drugs and Veterinary Dispensary bills ..	100	14	0			
" Stationery, etc.	26	3	0			
" Manure purchased	50	0	0			
" Contingencies	285	6	3			
" Cost of ensilage	70	15	0			
" Value of live stock purchased ..	229	13	0	7,188	15	0
				7,188	15	0
Credit				376	1	4
Total ..				7.565	0	4

Government House Dairy and Farm.

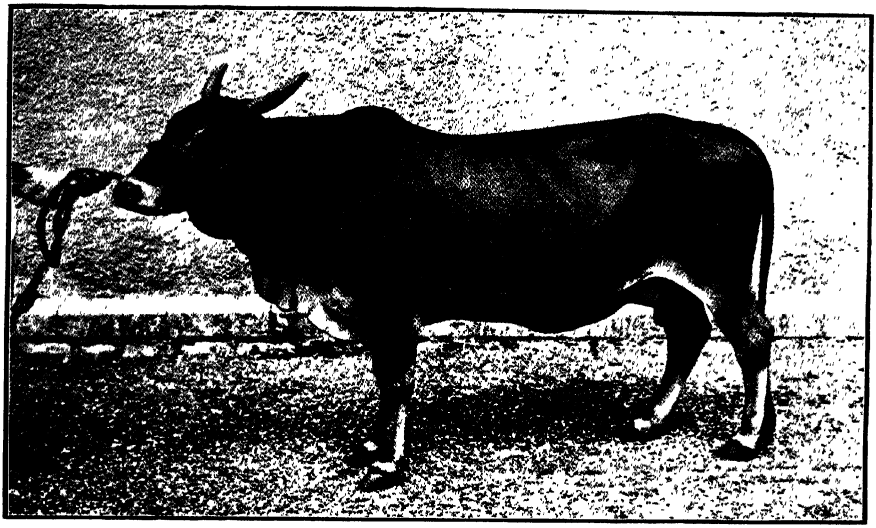
Statement of Accounts from **1st** *April* 1916 *to* 31st *March* 1917.

Cr.

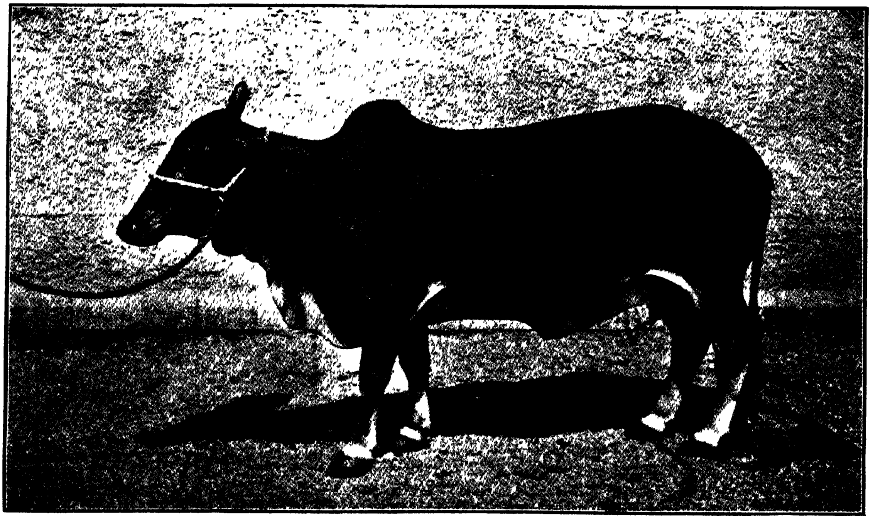
	Rs.	A.	P.	Rs.	A.	P.
By Income of milk, etc.	4,663	10	0			
" " lucerne grass sold ..	1,471	13	3			
" " *kadbi* sold	265	0	0			
" Value of live stock sold	3,474	0	0	9,874	7	3
" Stock of lucerne grass, *kadbi*, and hay in hand on 31st March 1917, to be debited to next account				2,296	0	0
TOTAL ...				12,170	7	3

Dr.

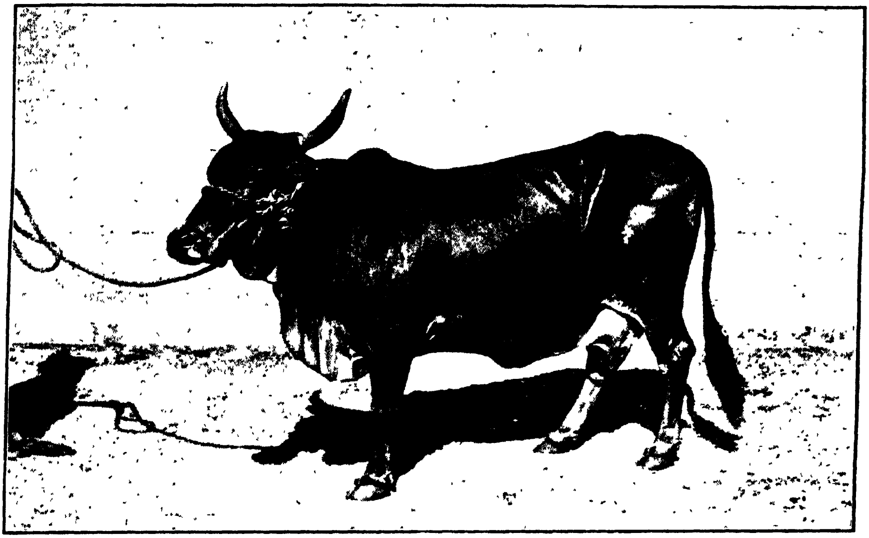
	Rs.	A.	P.	Rs.	A.	P.
To Stock of lucerne grass, *kadbi*, and hay, etc., brought over from last account ...				1,620	0	0
" Establishment and labour	1,947	2	11			
" Ploughing expenses	205	8	0			
" Hay making do.	65	8	6			
" Value of seeds purchased	614	12	3			
" " fodder do.	3,395	0	2			
" Railway freight, etc., and allowances ...	1,039	5	6			
" Value of dairy appliances and repairs ...	42	12	0			
" Drugs and Veterinary Dispensary bills ...	164	6	0			
" Stationery, etc.	110	6	0			
" Manure purchased	69	9	0			
" Contingencies	648	12	0			
" Cost of ensilage	67	6	3			
" Value of live stock purchased ...	261	2	0			
" Interest on capital (buildings Rs. 12,000, and purchase of stock Rs. 3,000) @ 5 % ...	750	0	0	9,381	10	7
				11,001	10	7
Credit				1,168	12	8
TOTAL ...				12,170	7	3



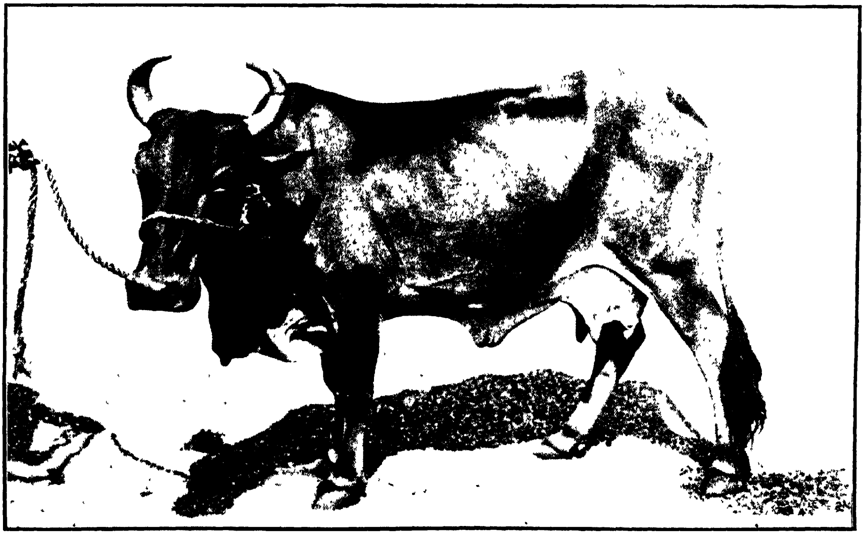
SUNDER.



KRISHNI.

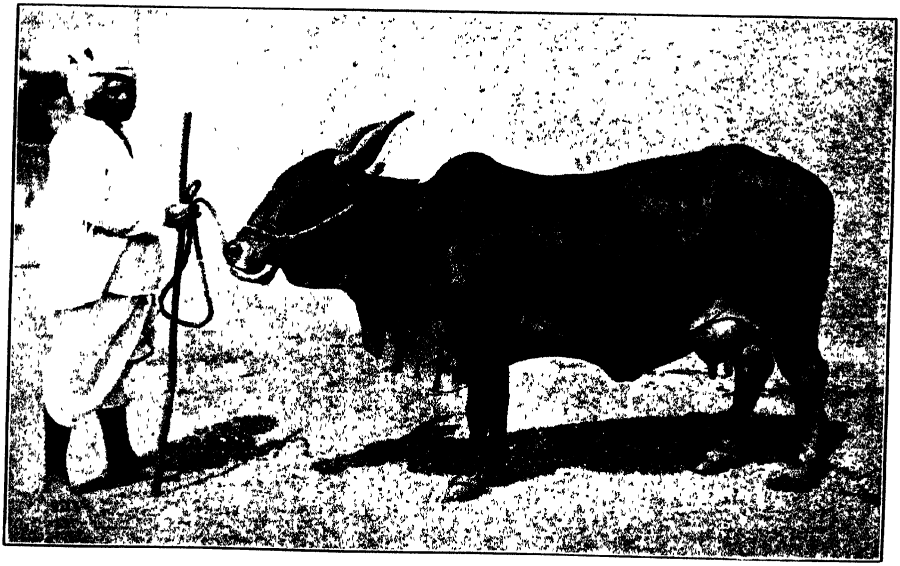


RADHI.



LALI.

MOR.



MARI.

LIST OF COWS IN MILK.

The Property of H. E. Lord Willingdon, G.C.I.E.

No.	Name of cow	Date of birth	Date when purchased	Purchased from	Sire	Dam	Calf	Amount of yield of milk for 12 months April 1916—March 1917	Date when calved	Date when covered	REMARKS
								lb.			
1	Sunder	1907	1913	Govt. House	Battasha	Pilwari	5th	2,593¼	17-8-17		
2	Krishni	1909	do.	do.	do.	Sawali	3rd	1,190¼	3-5-16	19-11-16	Sold on 20th Sept., 1917
3	Rungi	do.	do.	do.	do.	Pilwari	4th	3,245½	6-6-17	20-7-17	Sold on 20th Sept., 1917
4	Radhi	Not known	21-6-13	Milty. Dairy	Not known	Not known	8th	1,435½	31-3-17	29-6-17	
5	Nandi	do.	do.	do.	do.	do.	8th	2,635½	2-12-16	1-2-17	Sold on 20th Sept., 1917
6	Lali	1-1-07	do.	do.	do.	do.	5th	3,760	13-4-17	11-8-17	
7	Mor	Not known	5-8-13	Karachi	do.	do.	7th	14	22-2-17	8-5-17	Sold on 20th Sept., 1917
8	Mari	do.	27-8-13	do.	do.	do.	6th	4,100	13-4-17	15-8-17	
9	Luckdi	do.	5-8-13	do.	do.	do.	7th	4,387	1-9-16	18-1-17	
10	Luxumi	do.	12-8-13	do	do.	do.	8th	2,384¾	13-8-17		
11	Shevanti	do.	May 1914	do	do.	do.	4th	3,217¾	28-7-17		
12	Piri	do.	do.	do.	do.	do.	4th	3,713¼	16-2-17	14-7-17	
13	Yeshi	do.	do.	do.	do.	do.	5th	4,175¾	31-8-17		
14	Tulsi	5-2-14			do.	Tapti	1st		21-2-17	13-7-17	
15	Mahaluxumi	11-11-14			Sarja	Mari	1st		24-4-17	do.	
16	Tansa	3-1-15			do.	Tapti	1st		4-8-17		

WHEAT VARIETY TRIALS IN THE PUNJAB.

BY

W. ROBERTS, B.Sc.,

Principal and Professor of Agriculture, Agricultural College, Lyallpur.

THE Punjab wheats were preliminarily classified by Mr. Howard in 1906 and handed over to the Economic Botanist of the Province in 1908. The comparative testing of these and later of Pusa wheats at the Lyallpur Farm from 1909 to date will be discussed in the present paper. The early trials are notable with regard to the persistence with which we believed in Punjab No. 9, while the later ones conclusively show Pusa No. 12 to be inferior in yield under ordinary conditions to the local No. 11 and even to Punjab No. 17 in certain seasons at least.

For the sake of clearness the trials will be considered under two heads, *viz.*, (I) Variety experiments with Punjab wheats (as classified by Howard), and (II) Trials of Pusa wheats *versus* Punjab wheats.

I. EXPERIMENTS WITH PUNJAB WHEATS.

What appeared to be the best bearded wheats, *viz.*, Nos. 8, 9, 10, 11, 12, 13, 15, and 1 were received from the Economic Botanist and were tried in 1909.[1]

	Type No.	Previous crop	Yield Mds.	Yield Srs.
Sq. 26	8	Wheat	21	10
	9	*Senji* (*Melilotus parviflora*)	27	30
	10	Fallow	17	10
	11	Wheat	26	10
	12	Gram	21	0
	13	Wheat	21	30
Sq. 25	14	*Mash* (*Phaseolus*) (failed)	17	10
	15	*Arhar* (*Cajanus indicus*) (failed)	18	24
Sq. 26	1	Maize	21	11

Mr. Milligan, who was acting for the writer in 1910, wrote as follows :—

"The wheat variety experiment shows two outstanding crops (types Nos. 9 and 11) yielding 27 maunds 30 seers and 26 mds. 10 srs.

[1] *Report on the Operations of the Department of Agriculture, Punjab*, for the year 1909-10.

per acre respectively. The net value of the former was less than that of the latter, owing to the heavier labour bill involved in cutting a lodged crop. The grain, however, of this variety is much superior to that of No. 11, which produces a soft white wheat. Type No. 11 has shown a remarkable power of standing, which is a very important point in the surrounding district."

It will be noticed that no comment is made on the fact that No. 9 followed a leguminous crop. The crop was luxuriant to start with, and both Mr. Milligan and the writer were expecting great things of No. 9. The straw of No. 9 is a good deal stronger than that of No. 11. No. 9 had come out well with Mr. Milne in 1908 and had given good milling tests.[1] In 1910-11 the writer commented as follows[2] :—

"These two types were grown on a fairly large area this season, No. 9 occupying 18 acres and No. 11, 16 acres. Type No. 9 stood better than No. 11 this year in every case where the crop was heavy. As a yielder, however, No. 11 heads the list in all cases where the two types were grown side by side (*vide* results in square 26, Statement XV, and in square 10, Statement XVI)."

The above shows the obsession under which we were suffering. No. 9 being believed to be the best wheat for good land had been sown in all the best plots, and comparative trials were limited to square 26 and square 10—the former representing good land and the latter comparatively poor soil (Statements XV and XVI).

STATEMENT XV.

(*Square* 26.)

Type No.	Area	Previous crop	Yield Mds.	Srs.
1	1 acre	Wheat	18	20
9	do	do.	20	0
11	do.	do.	20	26
12	do.	Fallow	16	30
14	do.	do.	21	3
15	do.	do.	17	21

[1] *Report on the Operations of the Department of Agriculture, Punjab*, for the year 1908-09.

[2] *Report on the Operations of the Department of Agriculture, Punjab*, for the year 1910-11, paragraph xiii.

STATEMENT XVI.

(*Square* 10.)

Type No.	Previous crop	Yield Mds. Srs.
1	*Mash* crop (*Phaseolus*)	9 28
9	do.	9 9
11	do.	12 20

In 1911-12, the writer remarked as follows[1] :—

"Types Nos. 9, 13, and 11 were grown in acre areas side by side, the previous crop being cotton and *senji*, the other three types Nos. 12, 14, and 15 were adjacent, but followed wheat as a previous crop. The differences in the yields will be noted. Type No. 13 has done very well this year, and had been selected for special trial from the results of previous years. It is a *barani* wheat and grown largely in Gurdaspur, Jullundur, and even in Ferozepore. Types Nos. 9 and 11 seemed to be very similar in appearance, but No. 11 was lodged to a much greater extent than No. 9. As in 1910-11, however, it has given a slightly higher yield than No. 9, though the latter yielded more in 1909-10.

"As regards types Nos. 9 and 11 generally, it may be noted that the average yield for No. 9 on the farm was 27 maunds 27 seers and with tenants was 18 maunds 25 seers, and of No. 11 on farm 18 maunds 4 seers and with tenants 14 maunds 14 seers. No. 9 was grown, generally speaking, in good land throughout, whereas No. 11 was often put in poor land, being regarded as a better yielder than No. 9 under unfavourable conditions. In good land even the yielding capacity of these two wheats is similar, but the straw of No. 9 is stronger and the crop stands much better and is for this reason better suited for good land than No. 11.

"It may be noted also that, from experience outside the farm this year, it appears No. 11 is easier to cut and thresh than No. 9 (*vide* Statement XXI)."

The year 1911 is interesting, as in that year some seed of No. 9 and No. 11 was issued for trial on a moderate scale to zemindars with the approval of Mr. Milligan, then in charge of district work in the colony.

[1] *Report on the Operations of the Department of Agriculture, Punjab,* for the year 1911-12, page viii.

The results showed the marked superiority of No. 11. The total rainfall for the year was under 8 inches and was 1·8 inches during the wheat-growing season, and canal water was scarce; thus the hardier wheat triumphed. Type No. 11 grown on 16 acres by zemindars yielded an average of 20 maunds, and No. 9 grown on 204 acres an average of 11½ maunds. The difference between the two wheats in yield is of course nothing like the scale which the above would indicate, but the superiority of No. 11 is clear. No. 9 still continued to give high yields in good land and with favourable conditions.

In 1912-13, Mr. Southern, who was acting for the writer, wrote as follows :—

" An exhaustive comparative test was this year made of types Nos. 9, 11, and 13, both on good and bad land, and the results are of interest in that they appear to confirm the conclusions drawn last year with respect to types Nos. 9 and 11. Last year it appeared that No. 9 was a variety of wheat suitable only for good land ; the yields this year are all in support of this. Types Nos. 9, 11, and 13 were grown on good land on acre blocks (1) after cotton, and (2) after wheat, with the following results :—

Type No.	After cotton Yield per acre Mds.	Srs.	After wheat Yield per acre Mds.	Srs.
9	28	0	21	35
11	26	8	25	26
13	24	16	21	22

" After cotton No. 9 yielded better than after wheat, the land being in better heart in the former case ; while No. 11 yielded almost equally well in both cases.

" On 14 acres of poorer land the same three types were grown side by side in plots varying from ¾ to 1 acre in extent. The average acre yields work out as follows :—

Type No.	Yield Mds.	Srs.
9	14	37
11	16	16
13	15	39

" In some of these plots, which are situated near a village and where consequently the land is rich, No. 9 gave slightly higher

yields than Nos. 11 and 13; while in the rest of the area, where the land is very light in texture, Nos. 11 and 13 did very much better than No. 9. It seems therefore from these results, and from the wheat survey which has recently been made in the Lyallpur District, that No. 11 wheat is the most suitable for the colony generally."

It may be noted here that in 1911-12 Mr. Hamilton, the then Director of Agriculture, who rendered many valuable services to the Department, inaugurated a system of surveys of wheat and cotton in important districts in the province.

The writer carried out such a survey in the Lyallpur colony in 1912, which showed that No. 11 occupied roughly 60 per cent. of the wheat area with a purity averaging 80 to 85 per cent., and No. 17 occupied 35 per cent. with a similar percentage of purity; less than 5 per cent. being under other wheats. After 1912-13, when the writer took over district work in the Chenab colony, Punjab type No. 9 was definitely discarded, as it had conclusively shown itself unprofitable under ordinary conditions. This wheat is still being tried in the Lower Jhelum colony at Sargodha, though the conditions are similar there to those at Lyallpur, and no useful result would appear to be gained by continuing the trials.

As far as Lyallpur is concerned, effort was made to concentrate on the spreading of pure No. 11. Wheat in the colony used to contain from 2 to 5 per cent. barley, but lately owing to the Department's efforts and to the reduction of the basis for buying wheat being reduced to 2 per cent. barley, the excess being paid for at half wheat rates, the percentage of barley has gone down appreciably, specially near Lyallpur where the percentage now is rarely over 1 per cent. and very often only traces of barley can be found. The spreading of a pure variety of wheat offers many difficulties not encountered with cotton, the chief being the large seed rate per acre and the difficulty of handling large quantities which are liable to damage by storing. To illustrate this, we may consider the case of a man who purchases one maund of American cotton seed. This suffices for 10 acres and costs Rs. 4-8. Such a cultivator would have nearly 40 acres under wheat, the proportion being roughly

4 to 1. He would therefore require 25 maunds of wheat if the seed rate is 25 seers per acre. This would cost him (at Rs. 4-8 a maund) Rs. 112-8. In spite of this the Department had 100,000 acres of No. 11 quite pure in the canal colonies this past season. The Local Government recognizing the value of the work are advancing money for wheat purchases this year, which will enable us to largely increase the area of pure No. 11 next season. The general standard of purity of all the wheat in the colony has made a distinct advance as testified by all exporting firms who have noted a marked change in the evenness of quality of the wheat being put on the market during the last two or three years. The extra profit which may be obtained by growing pure No. 11 is estimated as follows :—

	Rs.	As.
Half maund per acre increase over impure No. 11 with wheat at Rs. 3 8	1	12
Two annas a maund premium on 15 maunds	1	14
TOTAL ...	3	10

This is a very moderate estimate, as zemindars claim much higher yields, especially where No. 11 is displacing Punjab No. 17.

II. Trials of Pusa wheats *versus* Punjab wheats.

A great deal has been heard of certain Pusa wheats, and strenuous efforts from various quarters have been made to boom these, notably Pusa No. 12, in the Punjab. As the latter especially hasbeen given very thorough trials in the Punjab, and as these trials have been carefully supervised and conducted, it may be of interest to other parts of India, where this wheat is reported to be doing well, to have a summary of our experience here.

The first Pusa wheats were tried in 1911-12. Some of these were sent up mainly in connection with a study of the influence of environment which was being carried on by the Imperial Economic Botanist, and some were crosses of Punjab No. 9 to be grown alongside the latter. Of these types, Nos. 9e, Pusa 106, and Pusa 12 showed most promise. The following statements show they were no better than Punjab wheats.

Statement XXVI-A.

Type No.	Soil	Irrigations	Yield Mds. Srs.
Muzaffarnagar, Pusa	Calcareous* loam	4 waterings	16 0
Pusa 8 ..	do.	do.	17 24
Pusa 12 ...	do.	do.	18 32
Pusa 22 .	do.	do.	13 16
9e 1	Light sandy loam	3 waterings	20 4
9e 2 ...	do.	do.	21 28
9e 3 ...	do.	do.	19 4
9e 9 ...	do.	do.	13 8
9e 10 ...	do.	do.	9 32
9e 13 ...	do.	do.	14 20
Pusa 106 ...	do.	do.	16 4

* With tendency to *kallar*, hence requiring frequent irrigation.

Statement XXVI-B.

Type No.	Soil	Irrigations	Yield Mds. Srs.
9a 2	Good loam—some of the best on the farm	2 waterings	17 11
9e 1 ...		do	19 31
9e 3 ...		do.	16 11
9e 10 ...		do.	15 34
9e 9 ...		do.	16 23
9e 13 ...		do.	17 30
Pusa 106 ...		do.	21 30

Before proceeding further, it is necessary to refer to the question of waterings, as this has been criticized and may adversely affect the value of the tests. It should be noted that usually in the Lower Chenab Canal, when canal supply is of average quantity, the number of waterings after sowing is three, but this is by no means universal; several villages with excellent cultivators use from four to seven—the latter being unusual and confined to *kallar* land where the concentration of salt has to be kept down to secure a crop at all. When watered sufficiently, such soils yield very heavy crops. In ordinary years and in years of lower supply, the number of irrigations after sowing may be classified as follows :—

	Ordinary years	Low supply years, *e.g.*, 1915-16 and 1916-17
1 watering	2 per cent.	10 per cent.
2 waterings	10 ,,	58 ,,
3 do.	60 ,,	20 ,,
4 do. and over	28 ,,	10 ,,
No water after sowing	none	2 ,

In order to get as much area sown with wheat as possible, the sowing period has to be very extended, and wheat sowing generally starts about October 25th and ends about December 10th or even later. Some of the earlier sown wheat suffers from white-ant attacks, and this very generally is the deciding factor as regards the first watering. Cultivators do their best to postpone the first watering as it interferes with sowings, and early watering is known to be harmful. When white-ants attack the young plants, however, there is no choice and watering has to be resorted to. Harrowing young wheat has been a regular method at Lyallpur since 1910 both to encourage tillering and check white-ant attack. It has proved beneficial but not a complete cure.[1] This implement is meeting with good success in the colonies. Again, it would appear many people think the cultivator has no interest in economizing water. An elementary study of economics as it affects him should dispel this mistaken idea. The total charge for water-rate and "land revenue" averages about Rs. 10 per acre, whereas the gross value of an average crop of wheat is Rs. 60. There is every inducement therefore to sow as much as possible and gamble on winter rains and good canal supply. If the former fails, as they often do, canal engineers are swamped with applications for more water, and each good cultivator has some wheat which receives only one or two waterings. The yield generally expected depends directly on the number of waterings given, though of course differing for different fields. From a large number of observations by my assistants and myself and from the testimony of zemindars these yields average as follows :—

Number of waterings after sowing	Yield of grain
Nil	Nil to 3 maunds
1 watering	4 to 7 ,,
2 waterings	8 to 12 ,,
3 do.	13 to 16 ,,

It must be remembered that at Lyallpur the rainfall during the growth of the crop is rarely over two inches and generally much less ; *e.g.*, in 1915-16 the rainfall for the whole year amounted to 3·04 inches only, of which one inch only in three separate showers fell during the life of the wheat crop. Wheat is therefore in the

[1] *The Agricultural Journal of India*, vol. XI, part II, page 199.

Chenab colony almost entirely dependent on irrigation for its water supply. This would not appear to be the case at Quetta where, according to Howard, six or seven irrigations are usual, in spite of a winter rainfall of about seven to ten inches (10 inches is more than equal to three irrigations in the Punjab).

To resume, in 1912-13 the tests with Pusa crosses and No. 9 were repeated. Mr. Southern remarked as follows :—

"The remarks made in last year's report apply equally this year. Pusa No. 12 shows most promise. Pusa No. 106 has not done so well as last year, while type No. 9e is not liked as well as Punjab type No. 9."

In 1913-14 exhaustive tests were conducted to compare Punjab Nos. 11 and 17 and Pusa 12. The remarks in the Annual Report by the writer were as follows :—

"An exhaustive test was made this year between types Nos. 11, 17, and Pusa 12 sown both after wheat and after cotton. Each acre plot as in the case of *toria* (*B. Napus* var. *dichotoma*) was harvested in two parts, as the southern end of the field is more uniform and better than the northern end. Pusa No. 12 is an early wheat, and the conditions prevailing in the year under report were favourable to an early ripening wheat. As will be seen, type No. 11 gave the highest yield in any one plot, but the average of the two acres under each of the three wheats is as follows :—

Type No.	Mds.	Srs.
Punjab 17	16	9
Pusa 12	18	4
Punjab 11	18	4

"As will be seen, type No. 11 and Pusa 12 happen to be exactly equal. The test will be repeated. The yields are all low.

"Water was short and only two irrigations could be given. Yields in this square are rarely under 23 maunds."

In 1914-15 tests were repeated in square 26 and with eleven tenants when Pusa No. 12 was compared with Punjab No. 11. Results conclusively proved No. 11 a superior yielder.[1]

[1] *Report on the Operations of the Department of Agriculture, Punjab*, for the year 1914-15, page xxvii.

Again in 1915-16 the previous results were fully confirmed as the remarks of the acting Professor of Agriculture indicate :—

"The results agree remarkably with those of the last year, and in view of the fact that the experiment each year comes in rotation into different plots, are extremely interesting. The following is a summary of the last three years' figures :—

Type No.	1913-14		1914-15		1915-16	
	Mds.	Srs.	Mds.	Srs.	Mds.	Srs.
	After cotton					
Punjab 11	21	25	21	12	28	30
Punjab 17	17	22	20	27	28	22
Pusa 12	18	16	20	5	26	20
	After wheat					
Punjab 11	14	23	18	35	22	3
Punjab 17	14	36	17	37	18	33
Pusa 12	17	32	19	0	22	7

"After wheat, Pusa No. 12 does as well as, or slightly better than, Punjab No. 11, and better than Punjab No. 17, but after cotton the Punjab wheats do better.

"In the tests on the tenants' area, where the conditions as to cultivation, etc., are not quite so favourable, but resemble more those prevailing on ordinary zemindars' land, Pusa No. 12 gives a less yield per acre than either of the Punjab wheats, as may be seen from the following figures :—

Type No.	Number of tests	Total area		Average yield per acre	
		K.	M.	Mds.	Srs.
Punjab 11	10	41	10	20	6
Pusa 12		41	11	18	31
Punjab 17	4	16	5	17	23
Pusa 12		16	8	15	35

"Pusa No. 12 did better than Punjab No. 11 in only three of the tests ; and better than Punjab No. 17 in only one case.

"In the comparative tests between Punjab types Nos. 11 and 17 under the same conditions, Punjab No. 11 does distinctly better than Punjab No. 17 :—

Type No.	Number of tests	Total area		Average yield per acre	
		K.	M.	Mds.	Srs.
Punjab 11	10	36	16	17	22
Punjab 17		36	17	15	3

"Punjab 17 did better in only one of the tests.

"The corresponding figures last year were as follows :—

Type No.	Number of tests	Yield Mds.	Yield Srs.
Punjab 11	11	15	10
Pusa 12		13	31
Punjab 11[1]	11	11	6
Punjab 17		10	10

"Pusa No. 12 did better than Punjab No. 11 in only two of the tests and Punjab No. 17 did better in four cases.

"The characters of the wheat seasons of 1914-15 and 1915-16 were in many respects markedly different: 1914-15 was a year when rust and also shrivelling of grain were rather bad and yields were not high; 1915-16 was on the whole a good year for wheat grown under such conditions as prevail at our farm, and the tests are conducted on different plots each year, yet the annual results of these varietal tests are in almost striking conformity; this year's figures confirm those of last year, and emphasize the remarks made about these wheats in last year's report. The gist of these remarks was that these two beardless wheats, Pusa No. 12 and Punjab No. 17, give distinctly less yield than Punjab No. 11 under ordinary conditions. Only under certain conditions as to land, cultivation, and irrigation, the beardless wheats may yield as well as Punjab No. 11. But under such conditions as prevail on our tenants' land, they give a yield inferior to that of Punjab No. 11. And this inferiority is such that not only would Pusa No. 12 and Punjab No. 17 be less profitable under the prevailing conditions of our wheat trade, but they must remain so, unless and until these wheats of superior milling and baking properties command a very much better price per maund than Punjab No. 11. As yet this is not the case.

"On the strength of these results we are continuing our present policy of distributing in the districts mainly Punjab type No. 11. More extensive tests of Pusa No. 12 as against Punjab No. 17 will be made next year: the tests of these two varieties against Punjab No. 11 will be discontinued.

[1] This average is lowered by one plot, badly affected by *kallar*, which gave only 4 maunds and 15 seers (in case of Punjab No. 11).

"Varietal tests of wheat have now been carried out on a considerable scale at Lyallpur for many years, and in a great majority of the tests Punjab No. 11 has appeared to be the best yielding and most reliable of the commoner Punjab wheats. This is confirmed by our wheat surveys and our experience since this wheat was distributed in a pure state in the district, where it is now grown pure on a large and rapidly increasing scale. But we are continually testing new varieties, and there is not the slightest reason to suppose that Punjab No. 11 is the last word in wheat seed for these canal colonies. On the contrary, we hope it will be possible greatly to improve upon it. For the present, however, it has proved its all round suitability for this tract, and the superiority of another wheat must be thoroughly proved before Punjab No. 11 can be displaced." To this it may be added that as far as quality is concerned Punjab No. 17 is probably superior to Pusa No. 12.

In 1916-17 when Punjab No. 17 and Pusa No. 12 were compared extensively in thirteen separate tests under tenants' cultivation, the average yield of Pusa No. 12 worked out at 18 mds. 19 srs. per acre, and of Punjab No. 17 at 19 mds. 21 srs.

In three plots only did Pusa No. 12 beat No. 17. It should be remarked that the season was unfavourable for an early wheat like Pusa No. 12. Previous tests, however, have tended to show Punjab No. 17 superior to Pusa No. 12. Both Punjab No. 11 and Punjab No. 17 seem therefore to be superior yielders over Pusa No. 12 in the canal colonies.

New wheats. Since Howard's admirable preliminary classification which gave us the groundwork for the above trials, more varieties have been identified by Mr. Milne. Some of these, notably No. 8a and No. 8b, promise to rival No. 11 in yield and will be extensively tried in the coming season.

Tests at Gurdaspur (Eastern Punjab). It is not proposed to deal with all the tests since 1911-12. The annual reports of the Deputy Director and the yield statements will repay perusal. The remarks in last year's report are as follows :—

"These tests were carried out in the *barani* (rain tract) as well as in the *chahi* (well) area. On the *barani* area, the Pusa wheats

Nos. 110, 4, 12, and Punjab type No. 14 were tested against one another with Punjab No. 14 as standard. The results are in favour of local type No. 14. Pusa No. 110 was very badly rusted on the leaves and in the heads, and will be discontinued.

"Punjab No. 11 seems very well suited for irrigated lands and, taken all round, it is almost unsurpassable as an irrigated wheat. This is a bearded white wheat. Pusa No. 12 and Punjab No. 17 are both beardless white wheats, and there is little to choose between them for *chahi* lands : if anything the results are in favour of the local type."

Again : "Different Pusa wheats have been grown on this farm since 1911. Only two, known as Pusa No. 4 and Pusa No. 12, the most promising, have been kept on. Pusa No. 12 is now generally grown in the central districts. This year there were some 2,400 acres under it in the districts of Jullundur, Hoshiarpur, and Gurdaspur, and over 8,000 maunds of seed have been stored for future distribution. The behaviour of these wheats each year has been discussed in former reports. This was a very good year to test them against the local types, and, as the results show, they have not compared favourably with the latter, which do better under adverse conditions. These wheats do well in a good year, but they need comparatively better lands and better cultivation. I am very doubtful as to their suitability to poor lands and conditions. Pusa No. 4 needs even better conditions than Pusa No. 12. We are going to try it further, especially on good land and under irrigation, in the hope that it will do well under these conditions. It has an advantage over Pusa No. 12 of being absolutely rustless, while the latter is rusted even in the ears, and one cannot feel confident that a failure could not occur in such a wheat. Both these wheats are beardless and ripen all at once, and, however successful they might be, the area under them will always be, for this last reason, limited."

JOHNE'S DISEASE.

BY

A. LESLIE SHEATHER, B.Sc., M.R.C.V.S.,

Imperial Bacteriologist, Muktesar Laboratories.

In view of the recent discovery of the existence of Johne's disease in India, it has been thought advisable that a brief summary of our present knowledge of the disease should be published in this country.

In European veterinary literature, apart from that published in Great Britain, the disease is generally termed chronic pseudo-tuberculous bovine enteritis or paratuberculosis. To both of these names valid objections may be raised. In the first place, both imply some relationship to or connection with tuberculosis, and, secondly, the former name implies that only bovine animals are affected. It will be seen later that, apart from resemblances with regard to the morphological and staining characters of the causal organisms, Johne's disease and tuberculosis have practically nothing in common. It will further be seen that cases occur in species of animals other than bovines. The name Johne's disease has been adopted in Great Britain in preference to those mentioned above because it is free from these objections, it places on record the discovery of the disease by Johne, and because it is far less cumbersome.

Johne, in collaboration with Frothingham, discovered the disease in 1895, but no further reference to it appeared in veterinary literature until 1903, when it was reported to be widely prevalent in Holland. Subsequently its existence was detected in Belgium, Switzerland, and Denmark.

The first report on the existence of the disease in Great Britain was published in 1907.

Johne's disease is a chronic enteritis which under natural conditions occurs most frequently among cattle, but sheep, goats, and deer are also attacked.

Under experimental conditions it has been found possible to infect only those species in which the disease occurs naturally. It has not been found possible to produce the disease in small laboratory animals such as rabbits and guinea-pigs. This fact sharply distinguishes the disease from tuberculosis.

The organism responsible for the disease is a small acid-fast bacillus measuring, on an average, about two microns in length.

The bacillus cannot be stained by simple aqueous solutions of the basic aniline dyes, but the addition of some mordant such as carbolic acid to the solution renders staining possible. When once stained, the bacillus may be treated with strong solutions of mineral acids without losing its colour. It is for this reason that it is termed "acid-fast."

For many years after the discovery of the organism all attempts to cultivate it on artificially prepared media failed. It was subsequently discovered that artificial cultures could be obtained upon media containing either dead tubercle bacilli or extracts made from them. Even on such media growth is very slow, and some weeks elapse before the growth is visible to the naked eye.

In view of what has been said regarding the artificial cultivation of the bacillus, it appears to be practically certain that the organism is unable to multiply in the outer world in soil or water. From this it may be inferred that the disease never occurs sporadically, and must be considered as purely contagious. It must be remembered that, while the bacillus is probably incapable of multiplying in soil or water, it may be capable of retaining its vitality in such conditions for some length of time. That is to say, infected land may be a source of danger after diseased animals have been removed from it. Many difficulties beset the problem of ascertaining for what length of time land remains infective.

The infection is conveyed to healthy animals through the medium of food or water contaminated with the fæces of diseased animals.

The interval elapsing between the actual time of infection and the appearance of clinical symptoms is long, amounting usually to several months, and not infrequently exceeding a year. For this reason the disease is seldom detected clinically in animals less than 18 months old.

The earliest symptom is a gradual loss of condition in spite of a maintenance of appetite. This is associated sooner or later with diarrhœa. The diarrhœa is usually persistent but may be intermittent, especially if dry foods and astringent medicines are given. The disease progresses until the animal is reduced to a mere skeleton, and fæces are quite watery. The course of the disease is long, animals not infrequently surviving for more than a year after the onset of diarrhœa.

At the *post-mortem* examination of an animal that has actually died of the disease, the emaciated condition of the carcase is most striking.

The specific lesions of the disease are confined to the intestines and the associated glands. In uncomplicated cases the whole of the other organs are normal.

In advanced cases both large and small intestines are involved.

To the naked eye the lesions are very inconspicuous and, unless specially searched for, are likely to escape detection.

The parts of the intestine generally involved are the terminal part of the small intestine, the cæcum, and the anterior part of the large intestine. The lesions are usually most marked in the first of these situations. Reference must be made to the fact that there is no constant relationship between the severity of the lesions and the number of bacilli present in them. The lesions may be pronounced and the bacilli few, or the lesions may be very inconspicuous and the bacilli present in immense numbers. In cases in which the lesions are pronounced, these take the form of a thickening of the mucous membrane of the intestine. This thickening is not evenly distributed, with the result that the membrane is thrown up into ridges

and between the ridges it has a granular or bosselated appearance. These ridges must not be confounded with the wrinkles of the mucous membrane which are normally produced by contraction of the muscular coats of the intestine after death. The ridges found in cases of Johne's disease are due to the formation of new tissues in the substance of the mucous membrane and cannot be entirely obliterated by lateral stretching of the intestine. (Plate IX, fig. 1.)

As a general rule, the formation of ridges on the mucous membrane is not so pronounced in the large intestine and cæcum as in the small intestine, but the mucous membrane is frequently materially thicker than normal. In uncomplicated cases there is never any ulceration of the mucous membrane, and inflammatory congestion is either inconspicuous or absent. The cæcum not infrequently shows some degree of congestion especially at the ileo-cæcal valve.

The mesenteric and colic glands are usually somewhat enlarged and when divided appear abnormally moist. A small quantity of watery or milky liquid may actually drain away from the cut surface.

Special reference must be made to the lesions as they occur in the mesenteric and colic glands of goats infected with Johne's disease. In this species, and so far as is known in this species only, the lesions of the intestinal glands become necrotic and undergo caseation and calcification.

Examination of sections from a piece of diseased intestine shows that the lesion is essentially a productive one. In a specimen that has been prepared with every possible precaution to prevent mechanical injury, it is found that the surface epithelium is quite intact and apparently healthy. In the substance of the mucous coat, and in advanced cases in the submucous coat also, there is found a variable amount of new cellular tissue. The cells of which this tissue is composed are of the same type as those found in young tuberculous lesions, namely, epithelioid or plasma cells. Unlike the immense majority of tuberculous lesions which are nodular, the lesions in the intestine in cases of Johne's disease are diffuse. (Plate IX, figs. 2 and 3.)

PLATI

Fig. 1.

A portion of the small intestine ($\frac{7}{10}$ natural size), showing the wrinkled and granular appearance of the mucous membrane.

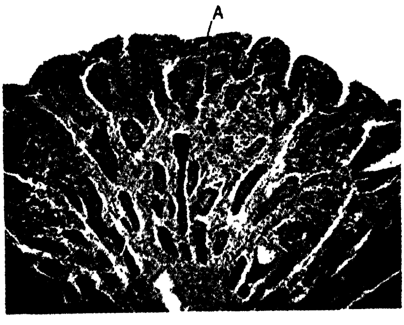


Fig. 2.

Section through the mucous membrane of the small intestine, showing the intact surface epithelium (A) and the infiltration of plasma or epithelioid cells between the glands of Lieberkühn (B.) (X 80.)

Fig. 3.

Section through the mucous membrane of the small intestine, showing the infiltration of plasma or epithelioid cells and a part of two of the glands of Lieberkühn. (X 500.)

Fig. 1.
Section through the mucous membrane of the small intestine, showing the thickening and distortion of the villi produced by the infiltration with plasma cells. (X 80.)

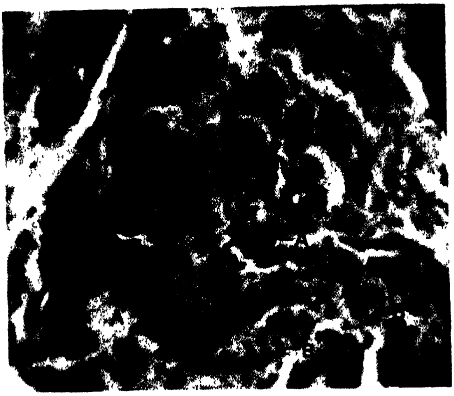


Fig. 2.
Section through the mucous membrane of the small intestine, showing large masses of bacilli (A) and small groups in which the individual organisms can be seen (B). (X 400.)

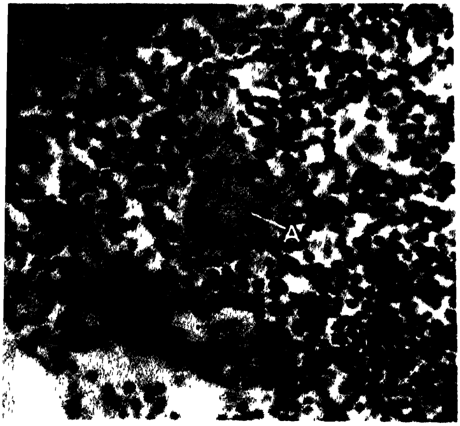


Fig 3.
Section of mesenteric gland, showing a giant cell (A). (X 500.)

Fig. 4.
A group of bacilli (A) in a preparation made from the mucous membrane of the intestine. (X 1000.)

If an individual cell is examined, it is found to possess a more or less vesicular nucleus and a considerable amount of cell body. The cells are rounded or oval in shape, but under mutual pressure become polygonal.

Villi that are invaded by these cells become markedly distorted and thickened. (Plate X, fig. 1.)

In sections that have been stained to demonstrate the bacilli, these are found to be present everywhere among the plasma cells, and not infrequently groups of them appear to be included within cells. (Plate X, fig. 2.) Occasionally a giant cell is to be found among the plasma cells. These cells have a large amount of cell body and a number of nuclei which are disposed in a more or less complete ring near the margin of the body. Bacilli are almost invariably found within these cells.

In sections from mesenteric or colic glands, collections of plasma cells are found. These are usually more numerous in the peripheral parts of the gland substance, and giant cells are found with greater frequency in the glands than in the intestines. (Plate X, fig. 3.)

Bacilli are frequently present in large numbers in the mesenteric and colic glands.

Diagnosis during life presents some difficulty. In places where the disease is known to exist, progressive wasting associated with chronic diarrhœa is sufficient to establish a diagnosis for all practical purposes.

In a small proportion of advanced clinical cases, the diagnosis may be confirmed in the following way. The arm is introduced into the rectum as far as possible and a small fragment of the mucous membrane is scraped off with the finger nail. This fragment of membrane is rinsed in water to clean it and is then used for the preparation of slides for microscopic examination as to the presence of bacilli. In spite of the fact that the intestinal wall contains immense numbers of bacilli, examination of the fæces is generally useless for diagnostic purposes.

In the early stages of infection a clinical diagnosis is impossible, because, as already pointed out, an interval of some months usually

elapses between the actual time of infection and the appearance of symptoms.

It has been discovered that in a proportion of cases a reaction follows the injection of tuberculin prepared from tubercle bacilli of the avian type. No opinion can be expressed upon such a reaction unless it is known that the animal is free from tuberculosis, because avian tuberculin will produce a reaction in tuberculous animals also. The value of this method of testing is further limited by the fact that animals in the early stages of infection and animals showing distinct clinical symptoms may fail to react.

A material has been prepared from the bacillus of Johne's disease in a manner similar to that in which tuberculin is prepared which can be used as a diagnostic agent. It is subject to the same limitations as avian tuberculin.

Diagnosis after death may be established by the detection of the bacillus microscopically. As already stated, the disease cannot be set up experimentally in small animals, and cultivation of the bacillus artificially requires a considerable amount of time. These methods therefore are inapplicable to the diagnosis of the disease as routine measures.

The following is the best procedure for arriving at a diagnosis. The whole of the intestines should be stripped from the mesentery and laid open from end to end. They should then be placed in a bucket of water and lightly rinsed. When free from ingesta they should be laid out on a long table with the mucous surface upwards and carefully examined for evidence of thickening of the mucous membrane. Parts showing a suspicious degree of wrinkling should be stretched laterally to see if the wrinkles can be obliterated.

It must be pointed out that a naked-eye examination alone is not reliable for the diagnosis of the disease, because bacilli may be present where there is no visible alteration of the mucous membrane.

The only method upon which reliance can be placed is to examine a number of preparations from the mucous membrane. A few slides may be made from suspicious-looking places first, but if microscopic examination of these fails to reveal the bacillus, about thirty films should be prepared from different parts of the

large and small intestines. As already indicated, the most likely parts for finding the bacillus are the terminal portion of the small intestine, the cæcum, and the first few feet of the large intestine.

It is most important to note that in making these preparations an actual fragment of the mucous membrane must be rubbed on the slide.

Up to the present no successful method of treatment has been discovered, nor is there any known method of protective inoculation. The administration of dry foods combined with astringent medicines may, in some cases, check the diarrhœa and lead to a great improvement in the condition of the animal. In experimental cases it has been found that no radical cure is effected, and that when the medicine is stopped the disease may rapidly gain the upperhand.

In many instances medicinal treatment does not modify the course of the disease at all.

Control of the disease is rendered extremely difficult by the following factors :—

(1) The disease is slowly progressive and has a very long period of incubation.

(2) Infected animals are a source of danger to healthy animals during the period of incubation.

(3) There is at present no means of arriving at a diagnosis during life upon which absolute reliance may be placed.

(4) There is no known method of successful treatment.

(5) There is no known method of protective inoculation.

In the present circumstances in India clinical examination must be relied upon. Any animal suffering from persistent diarrhœa should be killed and its intestines examined for confirmation of the diagnosis.

Very careful observation should be kept for animals falling off in condition. Such animals should be strictly isolated under observation, and should distinct symptoms develop they should be killed. The fæces of all suspected animals should be burnt.

Up to the time of writing I have had the opportunity of examining materials from three cases of the disease.

Case I. A piece of small intestine from a three-year old half-bred heifer. The lesions present were very slight, and examination of smears from the mucous membrane showed that typical acid-fast bacilli were present in small numbers. This animal had been losing condition for three months. It appeared anæmic and its coat was staring. At intervals its fæces were watery, greenish black in colour, and had a fetid odour.

In this case Johne's disease was complicated by parasitic gastritis.

Case II. A half-bred bullock. This animal had been losing condition for about two months. It arrived at Kathgodam station in an extremely weak condition, and died on the road about 4 miles from Muktesar.

The intestines were removed from the carcase and brought in for examination. On arrival they were found to be in an advanced state of putrefaction which made examination as to the presence of lesions difficult, but did not prevent a positive diagnosis being arrived at.

Twenty smears were made from the small intestine and ten from the large. Examination of these showed that the bacilli were present in small numbers in the former and in rather large numbers in the latter.

A number of the mesenteric and colic glands were examined and bacilli were found to be present in numbers varying from a score to a hundred or more in every field of the microscope.

Case III. A cross-bred cow about two and a half years old which was sent to Muktesar for examination.

The animal had been losing condition for about two months, and at the time of arrival at Muktesar, on May 23rd, was in an extremely emaciated condition.

On the 25th of May, preparations were made from fragments of mucous membrane removed from the rectum, but prolonged microscopic examination of these failed to reveal the bacillus of Johne's disease.

The animal was kept under observation until June 20th when it was found down and unable to rise. It was therefore killed, and a *post-mortem* examination made at once.

With the exception of the intestines the whole of the organs appeared to be normal. The intestines were stripped from the mesentery, laid open, and spread out on a long table for examination. There was slight thickening of the mucous membrane at a number of places in the anterior two-thirds of the small intestine, and in the last fifteen feet the mucous membrane was distinctly thickened and had a granular appearance. The wrinkling of the membrane was not so pronounced as it often is. There was distinct thickening of the mucous membrane of the cæcum and the first six feet of the large intestine. All the mesenteric and colic lymphatic glands were appreciably enlarged and very œdematous. In this case twenty-nine preparations were made from different parts of the mucous membrane of the small intestine and fourteen from the large intestine.

Johne's bacillus was discoverable in every one of the preparations with the exception of three made from the terminal part of the large intestine. This is in agreement with the examination of the preparation made from the rectum during life and indicates the uncertainty of this method of diagnosis.

The bacilli were most numerous in the preparations made from the small intestine at about the junction of the middle and posterior thirds where some hundreds were present in every field of the microscope.

Of the preparations made from the large intestine, those made from the cæcum were richest in bacilli. In these there were two or three groups, each containing a hundred or so in every field of the microscope. Microscopic examination of preparations from a number of the mesenteric and colic glands showed that bacilli were present in these in considerable numbers.

The photographs illustrating this note were taken from specimens obtained from this animal.

PRESENT POSITION AND FUTURE PROSPECTS OF THE NATURAL INDIGO INDUSTRY.

BY

W. A. DAVIS, B.Sc., A.C.G.I.,

Indigo Research Chemist to the Government of India.

I. HISTORICAL AND STATISTICAL.

THE IMPORTANCE OF THE INDIGO INDUSTRY.

INDIGO has been used as a dye in the East from the earliest times—in Egypt mummies dating back to the Eighteenth Dynasty (1580 B. C.) have been found wrapped in cloths dyed with it. Even at the present time it is by far the most important and valuable dye-stuff in use. The quantity consumed of this one dye represents in actual value not much less than the total combined value of all other aniline and alizarin dyes. The magnitude of the industry may be gauged from the following data.

In 1896, the year before the large-scale introduction of synthetic indigo, the export of natural indigo from India was 187,337 cwt., valued at Rs. 5,35,45,112 (£3,569,670), whilst from Java in the same year 680,000 kg. of a somewhat higher quality indigo (75 per cent.) were exported, having an approximate value, on the same basis as the Indian indigo, of £255,000. Thus the combined exports of these two countries in 1896 had a value of more than $3\frac{3}{4}$ million sterling. This estimate does not take into account the very large quantities of indigo consumed in India itself nor the exceedingly large quantities produced at the time and consumed in China and Japan. It is difficult accurately to estimate these, but some idea of the natural indigo formerly produced in the last two countries may be gained from the recent imports of synthetic indigo from

Germany and Switzerland into them. In 1913, 27,081 tons of 20 per cent. paste, having a value of £1,625,000, were imported into China and Japan. The German synthetic indigo had in these countries probably largely replaced the natural article formerly produced locally, as the export of Indian indigo to these countries was always small. But even in 1913 considerable quantities of natural indigo ("liquid indigo") were still being produced in China; the exports from the principal Chinese indigo-distributing ports were 70,357 piculs (1 picul = $133\frac{1}{3}$ lb.), having a value of 382,331 Hk. tls.[1] (1 Hk. tl. = 2*s.* $7\frac{1}{8}$*d.*) or roughly £49,575.

Neglecting therefore the smaller indigo-producing countries, such as Central America, Brazil, and the Philippines, the value of the total world's market for indigo under pre-war conditions considerably exceeded 5 million sterling. This value falls not far short of *that of all other artificial organic dyes put together* as can be seen from the following table showing the German exports of dyes; it must be remembered that Germany before the war supplied six-sevenths of the world's requirements in artificial organic dyes.

	1880	1890	1895	1900	1905	1907	1909
	tons	tons	tons	tons	tons	tons	tons
Aniline dyes	2,141	7,280	15,789	23,781	36,570	43,716 (£5,600,000)	47,777
Alizarin dyes	5,588	7,906	8,928	8,591	9,339	10,500 (£1,200,000)	34,784

Growth of the Synthetic Indigo Industry.

This is not the place to describe in detail the history of one of the greatest and most fascinating achievements of modern chemistry—the realization of what only 30 years ago was regarded almost as a dream—the manufacture on an enormous scale from coal tar of the valuable natural dye-stuff indigo. In the progress of organic chemistry indigo has played a most important part. It was from natural indigo that in 1841 Fritsche obtained aniline—the parent substance of the so-called aniline dyes. In fact the very word

[1] From data supplied by the Commercial Attaché, British Legation, Peking, to H. A. Lindsay, Esq., Director-General of Commercial Intelligence, India.

aniline is derived from the Arabic name for indigo (*anil*, the Hindustani *nil*). The apparent close relationship of indigo and aniline very early suggested the possibility of preparing indigo synthetically from coal tar, and so long ago as 1870 indigotin, identical with the blue dyeing principle of natural indigo, was actually synthesized by a chemical process by Engler and Emmerling. But a very long time—nearly 30 years—had to elapse before the manufacture of synthetic indigo could be established as a commercial success. During this period the problem was pursued persistently and without rest in the German universities and factories. The prize was one well worth winning—the capture of an industry representing at that time, when the aniline dye industry was of considerably smaller dimensions than at present, a money value far greater than that of all other chemical dyes put together. From 1865 to 1880 Baeyer with numerous pupils worked continuously on the problem and a complete synthesis of indigotin in 1880-1882 firmly established the structure of the indigo molecule.

Baeyer's processes were patented and purchased by the Badische Company for a sum of £20,000, and were worked on a large scale for some time. It was soon found, however, that these processes on a larger scale were an economic impossibility, because of the shortage of the world's supply of toluene—the substance which during the present war is being used in enormous quantities in the manufacture of the most powerful modern high explosive, trinitrotoluene (T. N. T.). In spite of the very large increase of production of crude tar which followed the introduction of the modern metallurgical coke furnaces—especially in Germany—the amount of toluene obtainable from crude benzene would only be enough to produce indigo sufficient to cover one-fifth or one-sixth of the whole consumption. An increase of the production of crude benzene for the purpose of obtaining more toluene would lead to over-production of unusable benzene and hence increase the price of toluene and, finally, that of synthetic indigo.

Although the Badische Company had incurred heavy losses by working Baeyer's processes, they did not hesitate to purchase in 1890 the patents of K. Heumann who had introduced a process

starting with naphthalene. This was the turning point of the indigo industry. Economically, this process was far preferable to the synthesis from toluene. Quite 50,000 tons of naphthalene were produced annually in the distillation of tar and at this time only about 15,000 tons had been utilized, the rest being left in the heavy tar oils or used in making lampblack.

But even working this process the output of synthetic indigo was not much increased until 1897 as shown by the following figures :—

	1880	1890	1895	1900
Export of synthetic indigo from Germany in tons	497	733	658	1,873

The obstacle was the fact that in the first stage of the process, the oxidation of naphthalene to phthalic anhydride, which was effected by heating the former with fuming sulphuric acid, the yield was poor. In 1897 a fortunate accident made the process a brilliant commercial success. From the breaking of a thermometer in the vat in which naphthalene was being heated with sulphuric acid and the keen observation of its effect by the chemist in charge dates the downfall of the natural indigo industry. It was noticed that the small quantity of mercury from the thermometer which fell into the sulphuric acid greatly accelerated the action and that a practically complete yield of phthalic anhydride was obtained. This is an example of a well-known phenomenon in chemistry known as catalysis, in which the presence of a trace of a third substance enormously influences the rate of interaction of two other materials. The case is a striking instance of how small a factor will determine the fate of a great industry. By taking advantage of this fortunate discovery the synthetic industry was entirely revolutionized. Not only was the first stage of manufacture carried out quantitatively by the presence of a trace of mercury, but it became possible to collect and use over again the large quantities of sulphur dioxide which were evolved during the treatment of the naphthalene with sulphuric acid. This sulphur dioxide was collected and utilized afresh by being converted into sulphuric acid by the so-called " contact " process.

The necessity of recovering enormous quantities of sulphur dioxide in the manufacture of indigo led the Badische Company entirely to modify the old system of manufacturing sulphuric acid. They perfected the so-called "contact" process, the principle of which had already been worked by Messrs. Chapman and Messel in London for several years on a relatively small scale. It is very difficult fully to estimate the indirect influence the synthetic indigo industry has had in Germany on other industries by facilitating the manufacture and cheapening the cost of sulphuric acid, the starting point of all other chemical processes. That the processes and plant introduced at this time have been an enormous factor in Germany's military strength is abundantly clear. Without the sulphuric acid plant of the Badische and allied factories Germany would have been deprived of one of her main resources. It was, too, no doubt, the lying idle of the liquid chlorine plant, which had formerly been used to supply the chlorine used in enormous quantities in a later stage of the indigo synthesis (the manufacture of monochloracetic acid), which suggested the use of chlorine for the early gas attacks which so nearly changed the whole course of the war at Ypres.

The magnitude of the changes introduced at this time into German chemical industry by the Badische Anilin und Soda Fabrik in the course of its indigo experiments can be gauged by a few data.

In 1888 the Badische Company produced 18,000 tons of sulphur trioxide catalytically and in 1900, 160,000 tons.

In 1901 the quantity of sulphur dioxide recovered by this process for the manufacture of phthalic anhydride alone was about 40,000 tons. The first artificial indigo plant was erected by the Badische Company at the cost of £480,000. In 1900 two competitors appeared, *viz.*, Messrs. Meister, Lucius and Brüning of Höchst-am-Main and Messrs. Geigy of Basle, the latter working Sandmeyer's process. The considerable fall in price of synthetic indigo which followed this acute competition led to Messrs. Geigy abandoning the field and to the amalgamation of the Badische and Meister Lucius indigo interests with a capital of £1,200,000. In 1910 the

Rathjen Company of Hamburg with a capital of £280,000 started making indigo, using an improved form of Sandmeyer's process, and von Heyden of Dresden, one of the largest dye-works of Germany, also took up the manufacture, working the so-called phenyl-glycine process. In Switzerland the Society of Chemical Industry in Basle began making indigo in 1911-1912.

Prior to the war the Germans, in order to meet the new Patent Acts of 1907, had founded works in England at Ellesmere Port, where the actual manufacture of indigo was carried out. But the necessary raw material—phenyl-glycine—was imported from Germany. When war broke out this supply was cut off, and, as the stages of manufacture were highly techn.. al, the Board of Trade kept the works going for a time under the German manager. For a time a little indigo was made but the output gradually came to a stop as the supplies of raw material gave out. In August 1916, the works were transferred to Messrs. Levinstein, an old established Manchester firm, who found that the scientific records of the works had been destroyed by the German manager before leaving, and that the plant had largely deteriorated owing to stoppage. Phenyl-glycine could not be obtained, and before operations could be begun a new method of making this substance had to be discovered, for no chloracetic acid could be obtained as this had been commandeered by the Government for special purposes.

The problem was rapidly solved by the chemical staff in the research laboratory and the works chemists, and within six weeks the first supply of phenyl-glycine was being made on a large scale in the factory, and in November 1916 synthetic indigo again came on the market in Great Britain. Since then the output has been steadily increasing. The war has also had the effect of greatly increasing the output of Swiss factories.

THE DISPLACEMENT OF NATURAL INDIGO BY SYNTHETIC INDIGO.

From 1897 onwards the output of synthetic indigo increased by leaps and bounds as the following table shows :—

TABLE I.

Export of Synthetic Indigo from the German Customs District.

Years	Tons
1895	658
1900	1,873
1901	2,673
1902	5,284
1903	7,233
1904	8,730
1905	11,165
1906	12,733
1907	16,354

These figures refer to the actual weight of goods exported and, according to the Badische Company's pamphlet ("Indigo Pure, B. A. S. F.," last edn., 1910 or 1911), the content of the material, mainly paste, may be taken on the average as 30 per cent. During the same period, the falling off in the exports of natural indigo due to the introduction of synthetic is seen from the following data :—

TABLE II.

Exports of Natural Indigo from India.

Year	Cwt.	Value
1894-5	166,308	Rs. 4,74,59,153
1895 6	187,337	,, 5,35,45,112
1899-1900	85,460	,, 2,08,78,818
From 1897 to 1906 there was a steady decline.		
Year	Cwt.	Value
1906-07	35,102	Rs. 70,04,773
1911 12	19,155	,, 37,58,025
1912-13	11,857	,, 22,01,325
1913-14	10,939	,, 21,29,070

Up to the year 1896 the advance in the prosperity of the Indian indigo industry had been almost phenomenal during a century. But the advent of the Badische processes brought about a rapid and steady decline until in 1914 only about one-twentieth the quantity of the high level mark reached in 1896 was manufactured and the total output from India had become almost negligible. It is important to note that nearly the whole of the exported indigo surviving in 1913-1914 (*viz.*, 8,752 cwt.) consisted of the higher grade Bihar indigo; the lower grade Madras indigo had practically ceased to be exported,

although in 1896 Madras produced more than half as much as Bihar and Bengal.

	1896	1913
	cwt.	cwt.
Exports from Bengal	111,714	8,752
,, ,, Madras	62,425	1,787

As regards the *area* under indigo, in 1895, 1,688,042 acres were devoted to this crop ; in 1914, before the war, the area had shrunk to less than 150,000 acres.

In 1880 India contained 2,800 indigo factories and 6,000 small works employing primitive methods of extraction, the total number of persons employed, exclusive of agricultural labourers, being 360,000. In 1911 only 121 factories remained (112 being worked by steam power) and the total number of workers had fallen to 30,795.

The fall in price due to the competition of synthetic indigo is shown by the following figures. In 1897 the price of natural indigo of better quality (60-70 per cent.) was 7 to 8 shillings per lb. (Rs. 400 to Rs. 450 per maund of 74·66 lb.). In 1914, before the war, natural indigo of the same quality had fallen in value to 3 shillings per lb. (Rs. 170 per maund).

EFFECT ON INDIGO IN JAVA.

The falling off in the production of indigo in Java in the same period is seen from the following table (*Oost Indische Cultures*, vol. III) :—

TABLE III.

Production of Indigo in Java.

Year	Kg.
1895	604,000
1896	680,000
1897	811,000
1898	904,000
1899	666,000
1900	595,000
1902	484,000
1904	483,000
1905	356,000
1906	192,000
1908	141,000
1909	92,000
1910	60,000

In 1910 the indigo industry in Java was almost extinct, only about 1,200 cwt. being still manufactured. It has had to yield to

the competition of the synthetic and its place has largely been taken by sugar manufacture.

EFFECT OF THE WAR ON THE INDIGO INDUSTRY.

When war broke out the supplies of synthetic indigo from Germany were immediately more or less completely cut off and a serious shortage of indigo was felt, which is indicated by the enormous increase shown in the following table[1] in prices realized at the Calcutta sales of natural indigo (good to fine), which take place in the months January to March.

TABLE IV.

Increase in Price of Natural Indigo due to the War.

Months	PRICE PER CWT. IN RUPEES			
	1913-14	1914-15	1915-16	1916-17
December	255	1,012	937	1,012
January	262	1,050	937	......
February ...	262	1,050	937	... ..
March	262	1,012	975	.. ...

In India arrangements were immediately made to increase the area of land under indigo, the result of which is seen in the following table :—

TABLE V.

Area of Land under Indigo in India.

Provinces and States	AREA IN ACRES			INCREASE + OR DECREASE − IN 1916-17 OVER	
	1916-17	1915-16	Average of preceding 5 years	Previous year 1915-16	Average of preceding 5 years
				Per cent.	Per cent.
Bihar and Orissa ...	80,601	60,800	83,000	+ 32·6	− 2·9
Madras	449,900	222,000	73,000	+ 102·7	+ 516·3
Punjab	57,400	21,400	32,900	+ 168·2	+ 74·5
United Provinces	159,300	43,200	24,800	+ 268·7	+ 542·3
Bombay and Sind (including Native States)	7,000	4,100	5,200*	+ 70·7	+ 34·6
Bengal	2,200	1,600	1,100†	+ 37·5	+ 100·0
TOTAL ...	756,400	353,100	220,000	+ 114·2	+ 243·8

* For two years. † For four years.

[1] From *Memorandum on the Indigo Crop of* 1916-17. Department of Statistics, India, December 21, 1916.

The total area under indigo in India was increased 3½ times in 1916-17, as compared with the preceding five years, but the total acreage, 756,400, was still less than half that occupied by this crop in 1895 (1,688,042 acres). The greatest increase, both relative and absolute, occurred in Madras Presidency and in the United Provinces where the industry is mainly in the hands of small holders and the dye is manufactured with simpler and less costly machinery but is generally of far lower quality (40 to 50 per cent. indigotin) than the Bihar make (60 to 70 per cent.). In Bihar, where the manufacture is carried on by large concerns, many of the factories and the machinery had fallen into a bad state of repair, and considerable outlay was necessary before extending operations. For this capital was often lacking owing to the leanness of the recent bad years. There was, too, a considerable shortage of qualified European supervision, owing to the fact that a large number of planters at the outbreak of war patriotically volunteered for service. On these accounts and because of special difficulties which will be dealt with later, the extension of cultivation was not so great in Bihar as in other provinces, and the increase of area in 1916-17 was only about 33 per cent. as compared with 1915-16 and there is an actual falling off of 3 per cent. as compared with the average of the five years preceding 1915. The actual increases of estimated yield of dye are given in the following table :—

TABLE VI.

Estimated Yield of Dye in India from various Provinces.

Provinces and States	Yield (in cwt.) of dye			Increase + or decrease − in 1916-17 over	
	1916-17	1915-16	Average of previous 5 years	Previous year 1915-16	Average of preceding 5 years
				Per cent.	Per cent.
Bihar and Orissa	10,900	7,100	11,700	+ 53·5	− 6·8
Madras	59,100	40,500	16,200	+ 45·9	+ 264·8
Punjab	9,900	2,700	5,400	+ 266·6	+ 83·3
United Provinces	14,100	4,000	2,900	+ 252·5	+ 386·2
Bombay and Sind	1,300	600	1,300 *	+ 116·7	..
Bengal	200	200	100 †	......	+ 100·0
TOTAL ...	95,500	55,100	37,600	+ 73·3	+ 154·0

* For two years. † For four years.

Madras Presidency is by far the principal producing area—the estimated output for 1916-17 being more than five times that of Bihar and Orissa and Bengal and nearly two-thirds of the total Indian production. The total production of indigo in India in 1916-17 (95,500 cwt.) is still only half that of 1896 (187,337 cwt.) prior to the increase of production of the synthetic dye which followed the introduction of the Badische processes in 1897.

The increase in actual *exports* of indigo caused by the war is shown in the following table:—

TABLE VII.

Exports of Indigo by Sea to Foreign Countries from Indian Ports.

	1911 12	1912-13	1913-14	1914 15	1915-16
	cwt.	cwt	cwt.	cwt.	cwt.
Calcutta	14,498	9,229	8,752	9,897	13,147
Madras ports ..	2,510	2,065	1,787	5,393	26,171
Bombay	434	320	173	1,426	2,565
Karachi ...	1,705	236	227	425	58
Rangoon .	8	7		1	1
TOTAL	19,155	11,857	10,939	17,142	41,942

The chart opposite prepared by the Department of Statistics, India, shows at a glance the variation in area and yield of indigo for the whole of India from 1907 to 1916.

COMPARATIVE STATISTICS OF NATURAL AND SYNTHETIC INDIGO SHOWING THE PRINCIPAL WORLD'S MARKETS FOR INDIGO.

The following recent statistics have been collected by the Indigo Committee of the India Office and were communicated to the Bihar Planters' Association and published in their Quarterly Journal, vol. III, no. 8:—

INDIGO STATISTICS.

Natural Indigo.

1. Export of indigo from India, reduced to a basis of 20 per cent. paste:—

	1910-11	1911-12	1912-13	1913-14	1914-15	1915-16
Tons ...	2,115	2,395	1,480	1,367	2,142	5,242

2. Average British import, consumption, and re-export of natural indigo on the same basis, 1906-14 (9 years) :—

British import	... ..	865 tons (20 per cent.)
,, consumption	... ...	385 ,, ,,
,, re-export	.. ...	480 ,, ,,

Synthetic Indigo.

(All figures on a 20 per cent. basis.)

3. Exports from Germany and Switzerland :—

			1913	1914, 6 months
	German export	..	5,000 tons	23,818 tons
	Swiss ,,	... .	2,191 ,,	1,648 ,,
	TOTAL	...	47,191 ,,	25,466 ,,
Value :—	German	.. ..	£2,666,100	£1,557,150
	Swiss	. . .	156,433	101,446
	TOTAL		£2,822,533	£1,658,596

Production.

4. In addition to above, are the quantities manufactured in England and France at the branch works and the home consumption in Germany, roughly :—

England	... .	2,000 tons
France	.. . .	2,000 ,,
Germany, home consumption	.	4,000 ,,
		8,000 ,, = £500,000 (about)
Total production of synthetic, 1913	.	55,000 ,, (about)
,, value ,,	... .	£3,300,000
Total production of synthetic, 6 months, 1914	...	29,500 tons
,, value ,,	... ...	£2,000,000

Synthetic.

The exports from Germany and Switzerland in 1913 were :—

Great Britain	... ...	1,180 tons (20 per cent.)
British Dominions	... .	998 ,, ,,
India ...	... ...	324 ,, ,,
Dutch Indies and Persia	... .	1,270 ,, ,,
United States	... ..	3,677 ,, ,,
China and Japan	... .	27,031 ,, ,,
Continent of Europe	... ...	12,229 ,, ,,
Sundries ...	... ...	523 ,, ,,
TOTAL	...	47,282 tons

Value of production for 6 months of 1914, £2,000,000

SOCIETY OF CHEMICAL INDUSTRY IN BASLE.

Export Trade of Indigo from Germany.

(Reckoned as paste.)

	January-December 1913	January-June 1914
	Kg.	Kg.
Belgium	312,800	175,900
Denmark	58,000	42,500
France	323,400	155,900
Great Britain	1,179,900	723,300
Italy	661,600	375,700
Netherlands	611,000	313,500
Austria-Hungary	6,804,000	2,337,000
Russia	2,170,000	1,305,500
Spain	335,000	142,000
Turkey	544,500	205,000
Egypt	433,400	251,500
British India	323,900	208,300
British Malacca	119,700	77,500
China	21,359,600	12,157,400
Japan	4,105,500	2,738,000
Dutch Indies	953,500	524,200
Persia	295,500	133,500
Canada	81,700	168,300
Mexico	94,000	17,000
U. S. A.	3,460,900	1,523,100
Australia	777,000	157,500
Switzerland	... ..	146,000
TOTAL	45,004,900	23,818,600
Value in marks	53,323,000	31,143,000

SOCIETY OF CHEMICAL INDUSTRY IN BASLE.

Export of Indigo from Switzerland.

(Reckoned as paste.)

	1912	1913	1914	1915
	Kg.	Kg.	Kg.	Kg.
Germany	2,500	... ..	..	......
Italy	32,100	36,400	73 500	58,000
Belgium	71,000	107,000	49,700	. ...
Holland	76,500	42,500	. ...	101,000
Russia	75,500	126,000	82,000	70,500
Sweden	52,000	75,000	30,000	......
Denmark	9,000	11,500	12,500	12,000
Dutch Indies	31,500	20,500	... .	......
China	371,100	1,290,800	1,593,400	118,400
Japan	94,500	326,500	349,500	38,000
U. S. A.	160,200	216,300	461,800	367,800
Sundries	800	2,100	3,000	2,300
Spain	......	12,000	106,500	122,500
France	......	.. ...	92,600	324,600
Great Britain	......	......	12,200	6,900
Portugal	... ..	......	41,000	......
British India	......	... ..	31,100	......
Australia	.....	......	30,000	......
Brazil	.. ..	. ...	......	3,200
TOTAL	976,700	2,266,600	2,963,800	1,225,200
Value in Frs.	1,509,502	3,910,838	5,072,307	2,251,427
,, £	156,433	202,893	... ..	.....

The figures of the exports of synthetic indigo from Germany and Switzerland to other countries are of special importance in showing the magnitude of markets other than those of Great Britain and the United States. It is seen that China and Japan consumed in 1913, 27,081 tons of indigo (20 per cent. paste), whereas the total consumption of Great Britain, British Dominions, and the United States of America together was only 6,179 tons. China and Japan together took three-fifths of the whole of the synthetic indigo produced.

The rapid capture of the Chinese market by synthetic in the course of about 7 years is seen from the fact that in 1906, when Germany exported indigo of a total value of 31·6 million marks, Japan was the principal consumer with 6·9 million marks, whilst China imported only to the value of 5·3 million marks. In 1913, of the German export of the total value of 53 millions of marks, China consumed indigo of the value of 21·25 millions and Japan 4·1 millions. In the past, the Chinese and Japanese markets consumed very little Indian indigo and satisfied their needs with home-made ndigo (water or liquid indigo) of a very inferior quality. The Germans apparently soon realized the importance of this enormous market which far exceeds that of all other countries put together, and, either by meeting the special requirements of these countries as to the form of the product they supplied or by convincing them of the superiority or greater cheapness of the synthetic article, have almost completely captured the trade in indigo in China and Japan. It is of importance in this connection to note that even in India considerable quantities of synthetic indigo were beginning to be used before the war, the export of synthetic to India being 324 tons as against 1,180 tons to Great Britain.

It is very clear from these data that the prosperity of the Indian industry and its ability to compete with synthetic in the future, will depend largely upon its being able to supply the Eastern markets. The British and American consumption is small by comparison.

The opinion has recently been expressed by Dr. G. T. Morgan in an article in the *Manchester Guardian* (June 30, 1917), that "the great increase of the output of natural dye since the war can only

be regarded as a temporary spurt. The synthetic dye is now too well established to be displaced." Apparently from the past history of natural indigo this was a safe conclusion. During the past eighteen months, however, I have found considerable evidence to show that, provided certain improvements in actual practice can be effected—they are clearly possible—the natural indigo will be able to put up an interesting fight with the synthetic dye. There are several different directions in which improvement is necessary if natural indigo is to compete with synthetic, failure in any one of which will greatly handicap the prospects of the natural dye. In future articles the present methods of manufacture and its handicaps will be dealt with and the possibility which exists of cheapening production and improving quality.

EXPERIMENTS IN STEAM-PLOUGHING.

BY

SIRDAR JOGENDRA SINGH

Editor of "East and West."

WE publish with much pleasure this racy paper by Sirdar Jogendra Singh who, in addition to his agricultural interests, is the well-known Editor of *East and West.*—[Editor.]

TWENTY years ago, I first began to think of some means of bringing a large area under cultivation for which I could not find tenants, and making it productive. I inherited an area of over 12,000 acres which was then yielding an annual rental of less than Rs. 20,000. The land was good, a light loam which was periodically renewed by floods, and the yields of crops that matured were generally very high. Most of the land was taken up by tenants who, in spite of large holdings and comparatively light rents, were poor and did not know how to help themselves. I made up my mind to live with them and for them—a resolution which I have not been able to keep.

My estate was situated in the backwater of the district. It did not possess even a *kacha* road. There was no hospital within an area of ten miles. The nearest post office was nearly nine miles away. It cost nearly Rs. 16 to carry 100 mds. to the district headquarters, a distance of 21 miles. The cultivation of economic crops was unknown. Large areas were lightly ploughed and sown, but the average yield of harvested crops was always poor. If the agriculturists, following a dry year, sowed maize, heavy floods swept the land and rich green battalions of maize withered away in

a day. If, on the other hand, rice was sown, the rains failed just when it was in milk, and no grain formed. The rents were paid in kind, and the people, by some strange logic, did not make the best of their holdings. The idea that the landowner took a good share of their produce, somehow deterred them from making any great effort. Long generations of poverty left them apathetic and unresponsive.

I began slowly by offering land at cheap cash rents, coupled with the condition that the tenant should grow either tobacco or sugarcane. I started at about Rs. 5 per acre, and now good land is in demand at about Rs. 15 per acre. The problem was to find suitable crops which would stand water-logging or a certain amount of drought. After experimenting with an indigenous variety of sugarcane it was found to stand a good deal of flooding, and the juice of the cane was examined by the sugar expert at Pilibhit and found satisfactory. The tenants found it so paying that in one year they placed a large portion of their holdings under sugarcane with the result that, with their limited means and primitive appliances, they failed to deal with the produce. The sugarcane kept the tenant and his whole family busy, and even then it was not crushed till March. The result was that his other land, which is so wet and grassy that all fallow land has to be dug up with a *kudali* and needs continuous work right through winter, remained unprepared. As a consequence the cultivation of sugarcane was dropped without any further investigation. I was not yet ready to provide them with a sugar factory capable of dealing with all their produce and relieving them from the slavery of the cane. In the meantime it was discovered that in dry areas *kudu*, a black millet, gave the highest yields.

All my land was gradually taken up, but there remained 2,000 acres of flood-swept area for which no tenants could be found. I had great dreams of lightening the burdens of the people, giving them better houses, and guaranteeing sufficient surplus as a food supply from crop to crop to each cultivator. The sight of underfed men, women, and children, driven to ceaseless drudgery from morning till evening to eke out a bare existence, seemed out of place

in this God's world. It seemed to me my first duty as a landlord to allow the land some rest, give fixity of tenure and easy rents so that the cultivator might get some confidence and take to more intensive methods of agriculture.

The difference in cultivation in lands which are given on rent in kind and those which are given on fixed cash rent is visible at once. The former are cultivated without much attention, while the latter are manured, harrowed, and kept like a garden with no corner left uncared for. It seemed to me that it was the duty of every landowner to work for the amelioration of his tenants. I must admit defeat, my dreams have not been realized—time has sped on, personal needs ceaselessly multiplying have absorbed funds which I wished to devote for my people. And it is a serious problem. It is such a shame that the labouring classes in the villages in Oudh and other parts of the United Provinces should not have even enough food from year to year. The talk of compulsory education and sanitation seems such a mockery. Going into a village in the United Provinces one is at once struck by the contrast between the physique of those who have had enough food and that of others who have only managed to exist somehow. The Brahman, the Rajput, and the cowherd are well-built and strong, while the poor village drudge is often a mere skeleton. He is practically bought for life by a well-to-do villager by an advance of Rs. 20 or 30 to pay up an old debt, and this advance binds him for life in lieu of a subsistence allowance, which the former allows him from crop to crop, of the coarsest and the most unmarketable grain. Better prices have helped in raising the wages, but the agricultural position has not very much improved even now. Is it fair that the landlord should skim off the cream of their labour and live on the fat of the land, while the producer is doomed to everlasting want, redeemed only by his patience and unquestioning acceptance of his "Karma"?

I wanted to farm on my own account to realize and understand directly the difficulties of the producer. I wanted to start steam-ploughing, but there was no road to my estate, and it seemed impossible to bring a heavy engine through ploughed fields and over deep *nalas* and rivers.

In the last famine, which Sir John Hewett managed with such great success, I took up the building of a road from Lakhimpur to Aira as an aided relief work. It provided work for hundreds, and the road remained to serve this part of the district which, in spite of its contribution to the local funds, had received no benefit. The *nalas* and rivers on the road have not been bridged, nor has the road been metalled.

I tried to get the road bridged and metalled, but failed, and decided to take all the risks. With the advice of Mr. Standley, who happened to be acting as an agricultural engineer, I procured a traction engine and then began the journey from Lakhimpur to Aira. The driver sent by Messrs. Burn & Co. declared it was impossible to carry the engine along. I persisted and it took nearly a month and a half to do the 21 miles. We pushed, we hauled the panting engine through soft soil and deep *nalas*, and a large stream was crossed by anchoring the cable to a tree and allowing the engine to work its way up. The driver protested, but the plan succeeded and we marched forward again. The engine had to be taken to pieces and placed on a ferry boat to cross another deep stream and put together again on the other side.

One evening the engine steamed in followed by crowds of villagers. Next morning we started the ploughing. The engine carried behind it a couple of gangs of disc ploughs which cut up a large sod without breaking it. The operation did not prepare the field for the seed—it needed re-ploughing. But even this first operation was not smooth working—the soil was of unequal density, and often in a single turning the engine sank in two or three places and hours were lost in hauling it on to firm ground. Mr. Burt, of the Agricultural Department, and Mr. Jeffery, of Messrs. Burn & Co., and a representative of Messrs. Ransome Jeffery & Co., all helped me with the experiment. The plough supplied by Ransomes was twisted in the heavy soil after an hour's work.

It became clear that on light grass-bound loams direct ploughing could only break the land at a cost which did not seem to me any the cheaper than the ordinary ploughing by bullocks. It meant the maintenance of ordinary ploughs and the required number of

bullocks in addition to the steam plough. The results of the experiments were described by Mr. Burt in an article which he contributed to the pages of the *Agricultural Journal of India* (Vol. IX, Part I).

The experience of taking the tackle across country for 21 miles was enough to preclude any further experiments with the heavier engines required in a double tackle. Experiments with an Ival motor tractor were no better. Mr. Johnson, of Messrs. Fowler & Co., recently told me that he has taken his engines almost everywhere and he could haul the engine through the river by an arrangement of cable and winding-drum.

It was about this time that land became available on the Lower Bari Doab Canal. It appeared to me to be the best opportunity to start a large plantation. A large English firm with experience of sugar manufacture, to whom I was introduced by Sir John Hewett, was prepared to set up a factory at its own expense, if I guaranteed the supply of a sufficient amount of cane. I, therefore, applied for an area of 15,000 acres and Sir Louis Dane was prepared to consider my application favourably. The expert opinion in the Punjab did not support the idea. I was not quite sure of being able to run such a large plantation. The risks involved were too large. I, therefore, abandoned the idea, and as a preliminary measure I applied for a grant of 2,000 acres for steam-ploughing in 1914, which was sanctioned in due course.

Mr. Haverty and I then selected the land and ordered the engines from Messrs. Fowler & Co. It was lucky that they were despatched before the war broke out. The tackle arrived in due course and it was erected by an expert European ploughman who was employed for six months. It was not, however, all smooth sailing in the beginning. The land had to be cleaned of brushwood, the roots to be taken out, and mounds standing in some cases several feet high had to be levelled. Then, when the ground was clean and absolutely level, the work was started. We did not do more than 5 acres on the first day, and for many days, on account of roots and other obstructions, the work was very slow, and people began to doubt the capacity of the tackle to run such

a large farm. The Irrigation Department had built watercourses which intersected the land and were found a great obstruction. Then, when we watered the land, the water ran all over and it was found impossible to plough the seed in. One of the engines sank in the soft soil right up to the fire-box, and Mr. Haverty and I passed a couple of anxious days till we discovered a solution.

The discovery was simple. It was simply to lay out water-courses and roads in such a way that the engines might have a dry road. The land is divided into rectangles of 25 acres each and it was decided to abolish the old watercourses and run one large watercourse on one side of each rectangle, the road to be on the outside of the watercourse so that the engines could always have a dry road. On the other side of the rectangle was put another ridge to protect the road on the corresponding side. This plan worked admirably. I am now able to cultivate 25 acres a day eight inches deep, and have broken the whole area. The steam-cultivation promises good returns for large farms, and I think the original idea of starting a sugar factory can now be worked. In the Punjab nearly 500,000 acres are always under cane, and crushing by a power mill and scientific evaporation without any improvement in the yield or quality of the cane would at least give to the peasant a profit of 25 per cent. on the crop he grows now. My idea is to set up a small factory which would deal with the produce of 1,000 acres and which any group of half a dozen villages could start on co-operative lines. Indeed, it is my hope that, if my experiments succeed, it will not only lead to the extension of sugarcane cultivation which is limited only by the capacity of the peasant to deal with the produce of a few acres, but help in fostering co-operative movement generally. The factory will be the beginning of village industries, the engine when free will pump water, gin cotton, press oil, thresh wheat, and these village factories could send the by-products to central factories run on up-to-date methods. I am now in negotiation with the Agricultural Department for the acquisition of another 2,000 acres so that I may be able to provide 1,000 acres under cane with a three-year rotation.

The cost of steam-cultivation may be worked as follows and will compare favourably with the highest rent that a landowner can obtain. The tackle, including a threshing machine and a seeder, cost me Rs. 50,000, to this must be added the cost of cleaning, levelling, laying out roads, watercourses, buildings and wells, another Rs. 57,000. The total capital expenditure may, therefore, be placed at Rs. 1,07,000, excluding the price of the land. The establishment charges come to Rs. 16,920 a year. The working expenses of the engines and the farm depreciation and renewals and interest are Rs. 22,960. To this must be added about Rs. 10,000 for Government land revenue and water taxes, plus Rs. 10,000 farm labour, which bring the total annual cost to Rs. 59,880.

The area that has been placed under crop has not exceeded 1,200 acres, as the water-supply is not available for more. The crops grown and yields can be approximately placed as follows :—

	Rs.
500 acres of cotton at an average of 6 mds. an acre = 3,000 mds. at Rs. 15 a maund	4[illegible]000
200 acres of oil-seeds, maize, etc., at Rs. 50 an acre	10,000
500 acres of wheat at 13 mds. an acre = 6,500 mds. at Rs. 3-8 per maund	22,750
10,000 mds. of *bhusa* at 2 mds. a rupee	5,000
TOTAL ...	82,750

Deduct Rs. 59,880 which leaves a net profit of Rs. 22,870 a year on an investment of Rs. 1,07,000. The profit would be almost doubled if the whole area could be brought under cultivation. Perhaps in a year or so I shall be able to tell the story of other advantages of steam-cultivation and crop experiments which are in progress.

THE CO-OPERATIVE DAIRY AT TELINKHERI IN ITS RELATION TO DAIRYING IN THE CENTRAL PROVINCES.

BY

D. CLOUSTON, M. A., B.Sc.,

Officiating Director of Agriculture and Industries, Central Provinces.

MUCH has been written of late years on the desirability of developing the dairy industry in India. Dairying, like most other industries in this country, is in the hands of an illiterate, conservative folk who are adepts at cheating their customers by methods of adulteration but are ignorant of the most elementary principles of dairying. The professional milkmen (*gowlies*) of the Central Provinces may be divided into two classes:—(1) *Gowlies* who live in the country and combine *ghi*-making with cattle-breeding; and (2) *gowlies* who live in towns and villages and make a livelihood from the sale of whole-milk. In towns milch cattle are sometimes kept by other castes, such as Kunbis, Telis, and Brahmins, but their number is small compared with that of the *gowlies*.

In the better grazing tracts in the north and east of the Provinces, where the cost of rearing cattle is so small that it pays to rear them for sale, *gowlies* prefer cows to buffalos, because of the demand which exists for bullocks as draught animals. In the more highly cultivated parts of the Provinces on the other hand, where the grazing areas are small and where cattle-rearing is for that reason more expensive, buffalos are preferred on account of the much larger yields of milk which they give per head.

There are three more or less distinct breeds of buffalos in the Central Provinces—a long-horned breed found mostly in the cotton tract, a short-horned breed found in the rice and wheat tracts, and a

very distinct breed, resembling the wild buffalo in appearance, found in some of the more jungly Zemindaris and Feudatory States of Chhattisgarh. The best specimens of the long-horned breed give from 7 to 8 seers a day when in full milk, as against from 5 to 6 seers for very good animals of the short-horned breed. Plate XI (Figs. 1 and 2) shows a specimen of each of these two kinds of buffalos. In the more jungly Zemindaris and Feudatory States of Chhattisgarh, where the cattle of the *gowlies* and *banjaras*, who are the professional cattle-rearers in those parts, have to compete with the wild buffalo, bison, sambar, and chital for the luxuriant herbage which Mother Earth produces in those wilds, the third type of buffalo mentioned above is found. It is known locally as the Sirguja or Deshta buffalo; that it is a cross between the wild and the domesticated breed may be gathered from an examination of Plate XI, fig. 3.

In villages in these jungly tracts frequented by the wild buffalo, old bulls of that breed frequently foregather with village she-buffalos, and crossing takes place. The Deshta or Sirguja buffalo, which I take to be the result of this crossing, is a large animal with well-developed neck, shoulders and horns closely resembling those of the wild breed. They are particularly strong as draught buffalos, but are much inferior to the other two breeds as milch animals.

From this short survey it will be gathered that in the Central Provinces there is no good breed of milch buffalos. An average herd when in milk does not give more than 4 seers a day per head. Our different breeds of cows are still poorer as milkers, two seers per day being the usual yield. The quality of the milk, given both by cows and buffalos, on the other hand, is very good. One hundred and forty-six analyses of buffalo's and 37 of cow's milk carried out on Telinkheri Dairy Farm last year, gave an average of 7·1 and 4·2 per cent. respectively of butter fat, while 19½ lb. of cow's milk and 11 lb. of buffalo's milk were found to give one pound of butter.

In the larger towns of the Central Provinces pure milk is dear and very difficult to get. From March till September the price in Nagpur is from 4 to 5 seers per rupee; during the rest of the year it can be obtained at from 6 to 7 seers per rupee. But it is by no

means easy to get really pure milk at any price, for the reason that the *gowlies*, who are the milk-vendors, do not supply pure milk except under compulsion, and few of their customers are in a position to exercise that compulsion which entails as a rule very close supervision of the *gowli* at the time of milking. Nearly all the milk sold in the larger towns is supplied by *gowlies* who keep their herds in or near the bazaars. The conditions under which that milk is produced and distributed are most insanitary. There is no pretence whatever at cleanliness. Their cattle drink from and wallow in dirty, scum-covered pools, and the milk is adulterated at times from the same source. The sheds and the surroundings are dirty in the extreme. Rotting dung, dust, and a pest of flies offend the eye at every turn.

Very little milk is brought into the towns of the Central Provinces from villages outside for the reason that there are no good grazing areas as a rule in the neighbourhood of the large towns, and the *gowlies* of the Central Provinces still rely much more on grazing than on stall-feeding. The towns have for that reason to be very largely self-supporting as far as the milk-supply is concerned. The want of good milk is therefore much more felt in the urban than in the rural areas of the Provinces, because in the villages there are large herds of cows which are commonly milked by the owners. The calves are starved in order that the villagers may have milk. Wealthy landholders will commonly maintain a milch cow or buffalo for private use.

There are three feasible methods by which the milk problem could be tackled in the towns :—(1) The purchase of milk produced in the villages and its distribution in towns could be organized through co-operative milk-sale societies; (2) the production and distribution could be run on co-operative lines; and (3) the production and distribution could be managed by a single individual or by a syndicate.

While the first of these systems is not only feasible but desirable in some parts of India where there is already a recognized trade in milk between towns and the neighbouring villages, in the Central Provinces it is impracticable for reasons already given. If the third system were to be adopted the whole organization would have to

be run by a good business-man or -men working independently of the existing *gowlies*. The second system is, I believe, the most promising under existing conditions in the Central Provinces. Like the third system it allows of thorough control: it goes further in so far it can be made to provide for the uplifting of the professional milkmen, *i.e.*, the *gowlies*, an important class in the Central Provinces. The Telinkheri Co-operative Dairy belongs to the second of these types. It is a co-operative concern which controls not only the production of the milk but its distribution as well. This Dairy Society—the first of its kind in India—owes its inception to Sir Reginald Craddock, Mr. Low, and Khan Bahadur Byramji. It owes its success very largely to the keen personal interest taken by the present Chief Commissioner in almost every detail of its working. This dairy was started five years ago. An article describing its working for the first two years will be found in the July (1914) number of the *Agricultural Journal of India* (Vol. IX, Part III). Since then minor changes in the management of the dairy have been effected. The herd maintained on the farm attached to the dairy now consists of 338 milch animals, of which 62 belong to Government and 276 to the two co-operative societies of *gowlies*. In addition to milch cattle there are 165 head of young stock. The statement below shows the quantity of milk, butter, cream, and *ghi* distributed during the last three years:—

	1914-15		1915-16		1916-17	
	lb.	oz.	lb.	oz.	lb.	oz.
Milk	220,754	8	300,714	12	267,384	12
Butter .	2,240	4	3,130	0	3,328	8
Cream .. .	817	10	979	8	825	4
Ghi	...		770	0	1,650	0

The profits made by the two societies last year amounted to Rs. 5,901-12-3. They have during the year increased the size of their herds considerably. They borrowed Rs. 4,200 from the Nagpur Central Bank, most of which has already been paid back.

The Government herd of buffalos are mostly of the Delhi breed; while those belonging to the *gowlies* are of the local breed. The buffalo stud bulls, all of which belong to Government, are of

the Delhi breed. The young buffalos being reared on the farm are therefore pure Delhies or crosses between the Nagpur and Delhi breeds. The cows of the dairy are a mixed lot, but most of them are of the Gaolao type. Some of them have been crossed by a bull of the Montgomery breed and some by a bull of the Ayrshire breed. In every case crossing is done with a definite view, namely, to establish a good milch strain. A young Gaolao-Ayrshire cross is shown in Plate XII, fig. 1, and a Montgomery-Gaolao cross in Plate XII, fig. 2.

The cross-bred heifers have not yet been tested as milch animals, as they have not given calves so far, but it is reasonably certain that the Ayrshire blood in the one case, and the Montgomery blood in the other, will add to the milk yield. As a draught animal the Montgomery-Gaolao cross has been tried for over a year and has proved a distinct success. He is heavier, less leggy, and keeps in better condition than the pure Gaolao bullock. He is slower in the yoke, but this is a positive advantage in this part of India where nervous fiery animals are physically damaged in a few years as a result of the careless manner in which they are handled by servants. It is still doubtful whether the Gaolao-Ayrshire cross will ever find favour on the plains as a draught animal, as he is deficient in bone and muscle, and feels the heat more than pure indigenous cattle.

The Government breed on the Telinkheri Farm is maintained for two reasons: (1) As a nucleus herd on which the dairy can rely for at least a small yield of milk daily; (2) as an improved herd for the breeding of bulls of good milch strains for the use of the *gowlies*. A nucleus herd belonging to the promoters of a pioneer dairy of this kind helps to reduce the risk of failure in the beginning before the *gowlies* have had time to be trained up to a sense of their responsibilities as co-operators. With a nucleus herd, experiments in breeding with a view to improve the milk yield can be carried out too.

There are now two co-operative *gowlies'* societies on the farm: in one there are 13 members and in the other 14. These societies are as nearly self-supporting as it is feasible to make them under

Fig. 1. AYRSHIRE—GAOLAO CROSS.

Fig. 2. MONTGOMERY—GAOLAO CROSS.

existing conditions. The members pay the following rates for food-stuffs :—

For grazing	As. 4 per month per animal.
Oilcakes	Wholesale price + 10 per cent. commission.
Juar (*A. Sorghum*) *kadbi* ..	200 lb. per rupee.
Clover	200 lb. ,, ,,
House rent	R. 1-8 per room per month.
Service of Government bulls	As. 6 per milch animal per annum.
Use of godowns and casks for storing food-stuffs ..	As. 2 per member per month.
For the use of aluminium milking pots ..	Anna 1 per pot per month.

The members pay Rs. 10 a month to the farm clerk for keeping their accounts. Nothing is charged for the use of the sheds provided by Government for their cattle, as against this is set the value of the cattle manure all of which is taken over by Government.

The milking, both of the Government herd and of the societies' cattle, is done under the supervision of the Overseer of the Dairy Farm assisted by one *kamdar* and three *chowkidars*. The members of the two societies milk their own cattle and get it weighed by the Farm Overseer who sends it on to the dairy. The dairy itself is the property of Khan Bahadur Byramji Pestonji, a most enterprising Parsee gentleman, to whom I have already referred in this article. He has entered into an agreement with Government to take over the milk at the rate of 8 and 8½ seers for buffalos' and cows' milk respectively. The prices of the various dairy products sold by him are given below :—

Butter, R. 1 per lb.
Cream, As. 12 per lb.
Whole-milk, 6 seers per rupee.
Whole-milk in bulk to milk-shops, 7 seers per rupee.
Separated milk, 16 to 20 seers per rupee.
Ghi, As. 12 per lb.

The milk is delivered either in bottles or in brass vessels, fitted with a tap from which the quantity required by each customer is run off. Short-distance customers are served with milk in bottles brought round in small hand-carts; while those who live farther away and institutions requiring milk in large quantities receive it from sealed brass vessels carried on coolies' heads. The great objection to this system of delivery is that the customers of the dairy, most of whom are from 1 to 3 miles distant, get their milk late in the morning. Arrangements are therefore being made for quicker delivery by establishing a motor service. This will enable the dairy to increase its sale of milk more especially in the bazaar.

It may be taken as an axiom beyond dispute that cleanliness in every phase of dairy management is of the very greatest importance and that care should therefore be exercised in the selection of a site for the dairy itself as well as for sheds for milch cattle. For the Telinkheri Dairy the following advantages in this respect are claimed:—(1) It is situated in the open country amid sanitary surroundings and is connected with Nagpur by first-class roads. (2) The sheds being on a hill the site is a dry one. (3) The Telinkheri tank affords an excellent supply of drinking water in the grazing area itself; this water is also used for the production of irrigated crops for the dairy cattle. (4) There is ample land on the dairy farm for the production of irrigated and other fodders.

Plate XIII, fig. 1, shows the cattle having their morning drink and bath in Telinkheri tank or reservoir before proceeding to the grazing grounds.

The grazing of about 1,000 acres available forms a very useful exercise ground for the herd, but the quality of the soil and grass produced is very poor. The soil being thin and stony, the predominant grass is spear grass (*H. contortus*). This is a short-season grass which springs up late in August and dries off again by November. It is an edible grass if fed before the spears develop, but it loses much in quality if left standing after that. There are small pockets of black soil scattered over the area and a block of about 60 acres of deep black soil in the valley adjoining the Telinkheri tank. The whole grazing area has been improved of late by

Fig. 1. DAIRY CATTLE HAVING THEIR DRINK AND BATH IN TELINKHERI TANK.

Fig. 2. GOWLIES GOING FOR DELIVERY OF MILK BOTTLES AND VESSELS.

removing the thorny shrubs and loose stones which previously covered much of the ground. The quantity of food-stuff yielded by grazing areas in this part of India is so insignificant that for any large dairy scheme the extent of the area available for grazing is only of secondary importance, so long as reasonably cheap, bulky fodders and concentrated food-stuffs can be obtained locally at moderate rates. The grazing area in this case, however poor though it be, serves a useful purpose as an exercise ground for the milch cattle.

Owing to the proximity of the dairy to a large town, *viz.*, Nagpur, the cost of cattle food-stuffs and labour is high. It does not pay, therefore, to rear young male stock on the farm. To rear female calves even is a very doubtful proposition from the financial standpoint as the statement below will show :—

For a period of—	Cost of rearing a buffalo calf	Value of female buffalo		Value of male buffalo
		Delhi	Local	
	Rs.	Rs.	Rs.	Rs.
One year ...	48	20	12	10
Two years	72	20	20	20
Three years	99	75	35	30
Four years	135	150	70	40

For four years the total loss on the rearing of male and milch buffalos of the local breed is Rs. 95 and Rs. 65 respectively, while the rearing of milch buffalos of the Delhi breed gives a net profit of about Rs. 15 per head. To reduce the cost of rearing them, all the young stock of the Government herd have been sent to a grazing ground 144 miles distant, which, forming as it does part of a plateau about 2,000 ft. high, is comparatively cool and affords fairly good grazing grass throughout the year. A small herd of milch buffalos has also been sent there for breeding purposes. This new breeding centre on the plateau will thus serve as the feeder farm for the Telinkheri Dairy. The cost of rearing cattle on it will only be a small fraction of what it is at Telinkheri, as the land belongs to Government and the grass on the plateau is so good that very little

in the way of "concentrates" has to be fed to the cattle. The breeding of improved milch cattle on separate farms, where grazing is cheap and plentiful, should, wherever possible, be taken up as an adjunct to any dairy scheme of this kind in the Central Provinces at least, for so long as good milch buffalos and cows can be obtained only by importing them from other provinces the cost of such animals must necessarily remain high. But given facilities for breeding equally good animals locally, there is no reason why we should not be able to develop both dairying and the breeding of good milch strains of dairy animals at the same time. To run a dairy with cows and buffalos, which give on an average two or four seers a day respectively, is not a business proposition, as the cost of feeding such animals runs away with nearly all the profit. The extra cost of feeding animals which give twice or thrice that quantity of milk is very small compared with the value of the extra milk produced.

To organize co-operative societies of *gowlies* requires a good deal of tact and firmness. After four years of training in honest dealing the *gowlies* of the Telinkheri Dairy now give the Department very little trouble and at times come forward even to assist the Farm Superintendent at busy seasons in stacking hay and storing food-stuffs. For 12 of the 27 members of the two co-operative societies, *pucca* quarters have already been built on the farm for which they pay at the rate of R. 1-8 per room per month. Quarters for the remaining members are being taken in hand. A primary school has also been built for them with the object of educating their children, and a depôt for the supply of human food-stuffs, such as wheat, pulses, *gur*, etc., has been opened on the farm for their benefit. All the profits made thereon are credited to the School Fund. Meetings of the two societies are held about once a month on an average to settle disputes between the members and to hear complaints. At these meetings fines are imposed on some and rewards are given to others according to their deserts. As a result of this training these *gowlies* have gradually developed into a comparatively well-behaved, law-abiding community, and correction is now seldom required.

That the Telinkheri Dairy has added greatly to the amenities of life in Nagpur is freely admitted by its many customers. But

we have as yet but touched the fringe of the population. There are still thousands of children in the poorer quarters of the city being fed on unwholesome food because the milk-supply is totally inadequate. Though it is very doubtful whether the high mortality among children in towns in India is due to any great extent to the want of milk, it is certain that the lack of such wholesome food accounts largely for the large number of puny, ill-developed mites which are so characteristic of city life in India.

The Telinkheri Dairy has served another very useful purpose in demonstrating what can be done in the way of developing dairying in these Provinces on co-operative lines. Proposals to start similar dairies have already been received from so many private individuals that it is evident that a separate staff will be required to organize dairies throughout the Provinces. For this work we shall require good practical dairy supervisors who can devote their whole time to the opening and supervision of new dairy concerns in the larger towns. We shall also require trained managers to be put in charge of these dairies, and as these will, in most cases, be responsible not only for the milk, but for milch animals and the supply of food-stuffs required for the same, they should be trained also in practical agriculture, including cattle-breeding. Supervisors and managers can both be trained quite well in India; but I would lay stress on the fact that we want men with a working knowledge of commercial dairying. The men at present turned out by our agricultural colleges prove hopelessly incompetent as a rule when tried as dairy managers. If there were more dairy concerns, it would be possible no doubt to put a large number of such men under training and to secure thereby a reasonable number of honest practical dairymen possessed of business capacity. I use the term honest because few realize how difficult it is in this country to get honest managers for business concerns of this kind. We want as supervisors men who are good organizers. To their knowledge of the science and technique of dairying, I would attach much less importance: these can be picked up in a very short time.

How to provide pure milk for Nagpur City is a question which is now being considered by the Local Administration. Our proposal is

to expand the Telinkheri Dairy by forming new co-operative societies of *gowlies*—a proposal which is both feasible and desirable. Another proposal is to start an additional dairy farm as an adjunct to the Sewage Farm to be run by the Municipality with the assistance of the Department of Agriculture. Both proposals are likely to be carried out.

Despite the fact that we have no outstanding milch breeds in the Central Provinces great developments in the improvement of dairying may be looked for in a few years. We look forward to this development because we believe that it will both add to the wealth of the country and at the same time help to raise the standard of comfort, more especially in towns. In England, America, Denmark, and other countries in the West, dairying has done more than perhaps any other branch of husbandry to tide the farmer over poor times consequent on the vicissitudes of the grain and meal market. With an animal of the milking capacity of the buffalo available in large numbers, there is no reason, as far as I know, why India should not become a large exporter of butter, if not cheese. It is the duty of Government to lay down the lines on which development is most likely to succeed, and to encourage private individuals and companies to work on these lines. Government can pave the way by improving the milch cattle, by running demonstration dairies, and by training dairymen.

It has been suggested in certain quarters that to meet the requirements of our large towns municipal dairies should be opened. This would no doubt be possible if Government were in a position to supply the staff and to exercise the necessary control; but to run even a small dairy requires far more skilled and personal supervision than could be given by a municipality: moreover, with the exception of those attached to military dairies, there are no trained dairymen at present available who could be safely entrusted with the management of a municipal dairy; nor would it be possible at present to find among the non-official members of a municipality men who are sufficiently interested in the subject to give a dairy the amount of general supervision required. Public opinion in favour of the development of dairying has in fact yet to be created in most parts of India.

WHEAT IN THE NORTH-WEST FRONTIER PROVINCE.

BY

W. ROBERTSON BROWN,

Agricultural Officer, North-West Frontier Province.

In the October (1916) number of the Journal, the writer explained how the out-turn of wheat at the Peshawar Agricultural Station in the year 1916 averaged 25 maunds per acre on an area of 60 acres. On behalf of the cultivators in the neighbourhood of the farm, who are believed to harvest only 12 maunds per acre, it was stated that over a period of several years the total value of the cultivators' small *do-fasli* crops is probably greater than that of the heavier *ek-fasli* crops harvested at the Peshawar Agricultural Station. Under any circumstances, it was submitted that the comparative smallness of the out-turns harvested by the cultivators in the North-West Frontier Province, is not to any large extent due to actual lack of knowledge or of skill in the cultivation of wheat, but their failure to secure heavy crops may more charitably be attributed to circumstances over which the cultivators have little control.

The last of this year's (1917) wheat crop at the Agricultural Station was gathered in on the 15th June, and as the average yield per acre on an area of 35 acres weighed 28 maunds 31 seers, it may be worth while considering why the crop is greater by so much as 4 maunds 24 seers per acre than that harvested in 1916.

Last year Farrer's Federation wheat occupied 3·4 per cent. of the farm wheat area and yielded 36 maunds per acre. Pusa No. 4, on 96·6 per cent. of the area, gave 23 maunds 30 seers per acre. This year the Farrer wheat was harvested from no less than 37·2

per cent. of the wheat land and yielded 31 maunds per acre. Pusa No. 4 occupied 62·8 per cent. of the area and improved its position by yielding 27 maunds 18 seers per acre. Federation, then, which has proved superior to Pusa No. 4 as a yielder, has produced less per acre than in 1916, but having been sown over a much larger area, it has contributed substantially to this year's high average out-turn, which is 4 maunds 24 seers per acre over the average yield of the previous year.

Pusa No. 4, on the other hand, has yielded 3 maunds 28 seers per acre more than in the year 1916. The percentage of land occupied by the two varieties and their respective out-turns are given below.

Year	Variety	Area in acres		Total out-turn in maunds	Average out-turn per acre		Percentage of total wheat area
					Mds.	Srs.	
1916	Pusa No. 4	60	58	1,378	23	30	96·6
1916	Federation		2	72	36	...	3·4
1917	Pusa No. 4	35	22	604	27	18	62·8
1917	Federation		13	403	31	...	37·2

In most respects the wheat received similar cultivation in both of the years under review. Over the greater part of the area wheat followed wheat after summer fallow; manure was given to 8 acres only; harrowing or intercultivation was not practised—cannot, indeed, be economically done on irrigated land in the Peshawar valley. In 1916 the rainfall during the life of the crop was 5·10 inches, and, in consequence, the wheat was irrigated three times, whereas one-half of the previous year's crop was irrigated once only and the other half received water twice.

Both of the wheats have yielded consistently well since they were first tried four years ago; both have remained almost entirely free of rust; and neither of them has lodged where wheat could be expected to stand up. Indeed, "though bladed corn be lodged and trees blown down" (Macbeth), Federation has remained upstanding since it was introduced to the North-West Frontier Province. In out-turn, Federation has yielded higher than Pusa No. 4; but in quality Pusa No. 4 is somewhat superior, and it is

also somewhat earlier. In upstanding power and rust-resistance they are about equal, and Federation does not "shatter" and is little affected by birds. The Australian variety appears to be practically immune to bunt. An upstanding, rust-resistant wheat is especially desirable in the North-West Frontier Province, where much of the land is very fertile, and the dull weather, followed by storms of wind and rain, which is frequently experienced in February, and sometimes in April, brings calamity to wheat that is not rust-resistant or has weak straw. It is the writer's opinion that the high yielding local wheat named Red Chaunthra has, for many years, encouraged careless cultivation of wheat throughout a large part of the North-West Frontier Province, because the cultivators have found that this variety lodges and suffers immoderately from rust when it is well treated. Federation is the chief wheat exported from Australia, and in all respects, except in the appearance of its grain, it is nearly the ideal variety for *ek-fasli* land in the North-West Frontier Province. Pusa No. 4 is unfortunately very liable to bunt. Wherever the writer has seen this variety in the field, it has shown a disquieting percentage of black bunt ears, or the growers have complained of the wheat's susceptibility to this disease. If Pusa No. 4 has Australian origin or parents this might account for its liability to bunt, as it is well known that many Australian wheats suffer severely from this disease. At Peshawar, despite treatment of the grain with copper sulphate, bunt has not disappeared from the variety, and Pusa No. 4 would not be accepted for distribution if bunt were not already common in Red Chaunthra. No bunt has been observed in Federation at Peshawar. Pusa No. 4 is, however, a great wheat, notwithstanding its liability to suffer from bunt and the presence of a rather large proportion of dark-coloured, blemished grains in an average sample.

After due consideration and after testing many varieties during the past six years, it was decided in 1916 to distribute free of all cost seed of Pusa No. 4 and Federation to sow over 2,000 acres of land, and to let the cultivators themselves decide if they preferred one of these varieties to their own vaunted Red Chaunthra. Federation was distributed in the higher, cooler valleys of the

Province not, however, because this variety ripened later than local wheat, but rather because Federation has not yet been fully tested on *do-fasli* maize-wheat land, and it is recognized that to obtain general favour in the North-West Frontier Province, a wheat must yield well even when it is sown somewhat late in November after the maize is cut.

Most of the fields sown with Pusa No. 4 were inspected by the Department's officers from time to time until the crop was harvested, and, with a few rare exceptions, the new variety has surpassed Red Chaunthra in all-round merit, including yield and quality of grain, although the season was dry and quite exceptionally favourable to the local variety, and also in spite of the fact that Pusa No. 4 did not germinate quite satisfactorily owing to the dangerously large percentage of the grain having been cracked or bruised by the steam-thresher. The result of the trial is that Pusa No. 4 has gained the cultivators' favour and has been accepted by them, and it is confidently expected that the variety will occupy the greater part of the 280,000 acres of irrigated land in the North-West Frontier Province within a very few years. On the wider unirrigated tracts, Red Chaunthra will be hard to displace, and if it must go it will probably give way to Pusa No. 12 which tillers freely and does well on unirrigated land but readily lodges on canal-irrigated fields. At the present time (19th June), the report on the behaviour of Federation on the higher valleys is not complete, but the one cultivator in the neighbourhood of the Peshawar Agricultural Station, who was permitted to try this Australian variety, harvested nearly 30 maunds per acre. Federation is a heavy yielding wheat, suitable, it is believed, for *ek-fasli* cultivation only, and it is improbable that it will become the popular variety in the North-West Frontier Province where wheat invariably follows maize on good irrigated land. But wheat is not exported to any large extent from the North-West Frontier Province, and there is no objection to the cultivation of several varieties. Pusa No. 4 has been so well received by the people that the North-West Frontier Province Government have allotted a sum of Rs. 25,000 to purchase seed from those growers who tested the variety this past season, and a further sum of Rs. 25.000 has

been set aside to build grain stores at some of the Tehsils in the Province, primarily to store seed of Pusa No. 4 for sale to the cultivators. Considerable difficulty may be experienced for a time in purchasing pure seed, as the cultivators thresh barley and wheat on the common village threshing floor, and already it has been discovered that the new wheat makes sweet white bread and, even at a premium of annas 4 per maund, the cultivators appear unwilling to sell the seed. But this difficulty should be overcome very soon.

In addition to the large block of Pusa No. 4 and Federation, an area of 5 acres was this year devoted to trials of varieties and to other wheat experiments, and the more important results obtained in these trials are given below.

VARIETY TEST.

Variety	Drill ft.	No. of irrigations	Out-turn Srs.	Out-turn Chks.	Rust Per cent.	Bunt Per cent.	Lodged Per cent.	Remarks
Pusa No. 4	180	3	20	14	0	5	0	Ripened second
Pusa No. 12	180	3	18	5	0	0	80	Ripened first
Cpr. No. 13	180	3	18	7	0	0	15	Ripened third
Federation	180	3	18	6	0	0	0	Ripened fourth
Red Chaunthra	180	3	14	4	100	3	100	Ripened last

Red Chaunthra became red with rust.

VARIETY TEST.

Wheat after Wheat for four consecutive Years; irrigated twice; no Manure.

Variety	Area	Yield per acre Maunds	Rust Per cent.	Bunt Per cent.	Lodged Per cent.	Remarks
Pusa No. 12	1 acre	20	0	0	75	Ripened first
Pusa No. 4	1 acre	21	0	5	5	Ripened second
Cpr. No. 13	1 acre	18	0	0	15	Ripened third

Pusa No. 12 was on the most fertile acre. The variety tillered well and promised the highest yield, but the crop lodged early. Cpr. No. 13 behaved like Pusa No. 12. No. 4 did not tiller well.

Great expectations centred on Cpr. No. 13, a new wheat of high quality bred by the Economic Botanist to Government, United Provinces, and it is disappointing that this variety has not yielded so well as Pusa No. 4 as in almost all other respects it proved at least equal to the Pusa wheat which is one of its parents, and Cpr. No. 13 was entirely free of bunt. It is possible that the United Provinces' variety may yield better after it is acclimatized, although it is improbable as the crop was very well grown, and 102 lb. of seed, most of which was sown broadcast in the customary manner, yielded 4,902 lb. of grain. But then that same quantity of Pusa No. 4 seed, less carefully grown and harvested, yielded 4,780 lb. It is noteworthy that 48 lb. wheat seed is the common seed-rate on irrigated land in the Peshawar valley and this quantity is sown at the Agricultural Station. Cpr. No. 13 will be tried again in the North-West Frontier Province.

In conclusion, Plate XIV shows an acre which produced alternate lines of sugar-beet and Federation wheat, and this area yielded 27 maunds 26 seers of good grain, and from 16 to 17 tons of sugar-beet.[1] This may very well form a record in the history of sugar-beet cultivation. All but one line of the wheat had been cut before the photograph was taken. The beet was sown on ridges at 24 inches apart on the 15th October, and the wheat was drilled between the lines of beet. The area was irrigated six times from the date on which the wheat was sown, and even during the wildest storms, one of which occurred when the wheat was in ear and immediately after the field was irrigated, no plant of Federation lodged. Manure was not given before or after the crops were sown, but the beet-wheat followed sugarcane and a summer fallow. The unusual experiment was undertaken to find out if the cultivators could secure even a small crop of wheat between lines of beet, to enable them to get a certain amount of grain for their bread, should they undertake to grow beet roots for a sugar factory.

[1] Twelve beet roots were sent to the Imperial Agricultural Chemist for analysis, and he reported that the average value for the 12 roots was as follows :—Sucrose 17·14 per cent., glucose 0·263 per cent., and fibre 5·247 per cent.—(W. R. B.)

PLATE XI

AGRICULTURAL BANKING IN THE DELTA OF BURMA.

BY

LAWRENCE DAWSON,

Barrister-at-law.

I. Introduction.

It will naturally occur to the readers of this Journal to ask what practical experience of agricultural banking a barrister-at-law has acquired to enable him to air his views on the subject. It is therefore necessary to say at the outset that the writer is the Managing Director of a small Bank which was incorporated in 1914. It is the first joint-stock bank opened in the mofussil of Burma for the purpose of financing the agriculturist, and is thus a pioneer enterprise in the field of agricultural banking.

The capital of the bank is small, *viz.*, Rs. 4 lakhs, and this is divided into 2,000 Ordinary and 2,000 Preference shares. Of this capital three-fourths has been paid up. The business was carried on by the writer on a proprietary basis before it was incorporated, and the capital was raised privately from depositors, who held deposits before incorporation, and who were guaranteed a minimum cumulative dividend of 8 per cent. with the right to share in any surplus profits to the extent of 25 per cent. The Company did not go to the public for its shares, because, as it happened, it could raise a sufficiency of capital from within. It may, however, be mentioned that, if the formation of the Company had depended upon public subscription, it is probable that it would not have been floated. The conditions of agricultural finance are not well understood, and the public has little confidence in mofussil enterprises of this description,

and is biased in its judgment by the views of professional bankers in cities, who are conservative in their ideas and have deep-rooted prejudices against the class of security that obtains in the mofussil. It was necessary to find an enthusiastic circle of friends, who, convinced of the possibilities, were willing to risk their money; and in this respect the vendor was fortunate. But even so, the flotation was successful, only because the shareholders were protected by preference rights and had a high rate of dividend, with the right of participating in further profits, guaranteed. In the event of a winding up, therefore, the loss, if any, would fall entirely on the vendor; for, he was paid in ordinary shares and not in cash, and more than one-half of the *par* value of these shares had already been sunk by him in the working capital of the business.

One-third of the shares are held by people resident in Scotland, the remainder by Scotsmen resident in Burma.

The bank was incorporated in October 1914 after the outbreak of war, and the present (1917) is the third year of its incorporation. Notwithstanding the war, the bank has justified the expectations of its shareholders, and has attained the position of a successful pioneer, but its sphere of usefulness is capable of being greatly enlarged, and its capacity for development is so considerable that the fact that even greater development has not taken place, must be put down to the causes already referred to in connection with the difficulty of raising capital.

II. Conditions under which the Agricultural Industry is at present financed in Burma.

Agriculture is Burma's chief industry, but the difficulties under which the Burman cultivator labours as regards the supply of requisite capital hamper the improvement of this industry. It is true that attempts are being made to deal with this situation, but they are inadequate and the methods followed not quite suitable. Let us examine the existing position in some detail, and then formulate proposals for improving the arrangements for financing the industry and the nature of Government assistance required to carry them out.

Rice is the chief crop of Burma, but from my experience, which is confined to Lower Burma and particularly to the delta, where the bulk of the crop is raised, I am of opinion that the production and disposal of the crop is hampered by the conditions under which it is financed by the Chetty, a money-lender from Southern India, who has no particular aptitude for agricultural banking. He is essentially a money-lender who is concerned with the realizable value of his pledge and with that only. He has done much for Burma, because he filled a place and supplied a want when there was no one either ready or willing to do it. But his limitations are both numerous and obvious. These are indicated below:—

(1) He is not interested in agriculture itself, and questions of the improvement of the soil or of improved husbandry do not appeal to him. He makes no attempt to contribute to their solution, and he will not finance such schemes.

(2) He does not particularly concern himself with the purpose for which a loan is raised, nor sees to it that the loan is applied to that purpose.

(3) He is not contented with legitimate business, and touts for loans and encourages the taking of them for unproductive purposes if the security is ample.

(4) He does not care about repayment in small instalments, and does not press for them, as he should, if he were merely a banker.

(5) He is not a sympathetic banker, and demands payment regardless of the plight of the agriculturist or his ability to pay, and generally makes the conditions of payment more difficult, when in the circumstances they ought to be made more easy.

(6) He is unbusiness-like, and encourages rather than discourages unbusiness-like methods.

(7) The temptation to over-reach the customer in technical matters proves almost too great to be resisted by him.

(8) He is relieved every three years by a new agent, and the system involves something like a triennial winding up

of the firm's local business. There is in consequence no guarantee of continuance in the financial relations between customer and banker, which are often seriously dislocated by the caprice of the agent's successor.

(9) His business is an unregistered partnership.

(10) His rates of interest are very high.

The large bulk of the Burma crop is still financed by the Chetty, and the agriculturist has maintained himself in spite, rather than because, of him. He is, as an agricultural banker, therefore, a failure and he is out of date.

The Burman agriculturist wants (*a*) a banker more sympathetic with his needs and aspirations, (*b*) a banker who can give him cheaper and better credit consistent with good security; and for these qualities he must look elsewhere than towards Southern India.

The rise in the market values of land in Burma in the last decade has been followed by a general improvement of the condition of agriculturists, and they have paid the Chetty rates of interest varying between 24 and 36 per cent. per annum; but these high rates have prevented them from making payments towards principal and building up a financial reserve; so that bad harvests or low prices may, at any time, cause a serious set-back in their economic position.

In this connection it may be mentioned that Mr. Maxwell Lawrie, M.V.O., Commissioner of the Irrawaddy Division, retired, pointed out to the present writer that he was understating the case about rates of interest by not doubling these figures, but we are referring to the Chetty who is not nearly so heavy in his charges as is the village money-lender whose rates often run as high as 60 per cent.

Owing to the scarcity of capital and to dear credit, the agriculturist in Burma cannot afford—

(1) to develop or improve land or bring new land extensively under cultivation;

(2) to build barns within which to winnow, thresh, and store his crop so as to avoid damage from unseasonable showers;

(3) to purchase improved implements or agricultural machinery;
(4) to experiment with other than the cheapest manures;
(5) to raise good stock;
(6) to insure his cattle or indeed anything;
(7) to grade his grain; and
(8) to hold his stocks up when the market is exceptionally low.

There are exceptions, but the above, I think, fairly represent the prevailing condition of the agriculturist. He is hampered at every turn by the want of capital and by high rates of interest, and it would be interesting to know what other great productive industry in the Empire suffers from these causes.

III. Measures adopted by Government for affording Financial Assistance to the Burmese Farmer.

We may now consider the attempts made to deal with this situation and the methods followed.

Government has so far employed two methods for affording financial assistance to the Burmese farmer, one direct and the other indirect.

The direct methods consist of legislative measures, and these are the Agricultural Loans Act and the Land Improvement Act; and the indirect methods are the propagation and the fostering of the growth of Co-operative Credit Societies and of a Central Co-operative Bank.

(a) *Direct Methods.*

The amount lent by Government, in the year 1915-16, under the Agricultural Loans Act, was Rs. 13 lakhs for the whole province, but under the Land Improvement Act no figures are given and the amount may be assumed to be negligible.

The Agricultural Loans Act No. XII of 1884. This Act was generously conceived. It provided for the relief of agricultural distress, and it is clear, both from the Act and the rules

framed under it, that it was not intended that its scope should be limited to cases of distress which are the result of natural causes like flood, drought, cattle disease, etc. It recognized that there might be genuine and unavoidable cases of distress arising from other than natural causes or theft of cattle, and it recognized no distinction between the holder of 30 acres and the holder of a smaller area.

Much distress might easily arise from the crop being marketed at an exceptionally low price, and distress often arises from the failure of others to fulfil their obligations, pecuniary or otherwise or both. The "Instructions" under the Act do not recognize such cases, and the relief that the Act affords is confined to very narrow specified limits. The Act is only a partial success for the following reasons :—

(1) only a proportion, probably small, of those who really need agricultural advances apply for them or get them:

(2) and, the converse proposition is also true, *viz.*, those who get the advances are not necessarily those who most deserve them.

It is worthy of remark that the low rate of interest charged by Government as compared with current market rates is, in this respect, not altogether an advantage. It makes the advances seem like prizes in a lottery, and produces the same effects on the fortunate few as the winning of prizes. Further, these advances may go in some cases to the wrong class of persons.

In my view, the making of agricultural advances, except in the case of widespread distress, is a branch of activity that is not suited to administration by Government, and it is perhaps because Government recognizes this fact that the relief it affords is cut down to such narrow limits. Considered as a measure of financial aid, this Act, with its Rs. 25 lakhs outstanding for the whole province, strikes me as very inadequate. The Chetties alone have given about Rs. 50 lakhs in loans to agriculturists in the single district of Pyapon, and the "distress" that they relieve is perhaps not less acute.

The Land Improvement Act. This Act is also very wide in principle, but the Rules framed under it, as well as the Instructions render the aid it offers illusory.

Rule 13 insists that the applicant's resources to carry out the improvement without a loan should be fully taxed ; so that, if his land is free, he should encumber it or even sell a portion to provide himself with the necessary funds, and the same rule lays down that no loan should be granted unless there is good and adequate security.

The applicant can, therefore, easily be impaled upon the horns of a dilemma, and he may be met in this way. If his land happens to be unencumbered, he may be told he has resources and therefore cannot get a loan; if not, he may be told that he has not sufficient security to offer and no loan can, therefore, be granted.

(*b*) *Indirect Methods.*

Government is more happy in its indirect methods, and its co-operative credit propaganda is attended with the best results. The propagation of co-operative credit societies and the fostering of their growth and influence have produced far-reaching effects. It is a substantial contribution to the solution of the problem of agricultural indebtedness, but it is apt to be forgotten that it is only a contribution, and notwithstanding the success that has attended co-operation in recent years, it is a mistake to expect too much from it, or to assume that in course of time, with the growth and progress of the movement, every agriculturist will respond to its *vade mecum*.

We all know that co-operative credit is the best form of credit, because it has an ethical as well as a commercial side. It requires on the part of co-operators certain qualities such as mutual trust, the habit of making punctual repayments, resisting the temptation to spend the loan in unproductive ways, the necessity of standing well with one's fellows : in short, a continual improvement in one's character. Hence it is that co-operation finds its limitations in human nature.

It is easy to be converted to its principles. It is difficult to act up to them. For a hundred that have " faith " there are few who

can prove their faith by "works," and the few are not always sufficient to leaven the lump.

In theory, co-operation should appeal to all, rich and poor. In practice, it appeals more to the needy, because they are under the strongest necessity. In certain districts in Upper Burma co-operation has thriven and is now a flourishing plant. In the delta its seed has fallen on stony ground.

Co-operative credit societies can do much, but they cannot do everything, and they are not best suited to solve problems of agricultural indebtedness in the delta, and Government should not rest satisfied with this single form of activity or take the view that in the dim and distant future agriculture will find its complete salvation in co-operation. The needs of the agriculturist are pressing and insistent, and if other methods are available and offer equal, if not greater, prospects of immediate or ultimate success, it appears to me that measures should be taken to investigate them. If, as the result of such detailed enquiry, these other methods appear to promise success, they should be adopted, and, in respect of them, Government should adopt a propaganda, not less energetic or enthusiastic than that adopted in the case of co-operative credit societies.

I need not add that any such investigation would be welcomed by this bank and that this bank would put whole-heartedly at the disposal of Government all its resources and would give all the assistance that lies in its power.

IV. Proposals for the Better Financing of Agricultural Industry in Burma.

Let us now proceed to a consideration of proposals for improving the arrangements for financing the agricultural industry in Burma and the nature of Government assistance required to carry them out. Here we at once find that the most urgent necessity is the establishment of banks in the mofussil. The type of bank required is a mortgage bank that will give the agriculturist long credit. It is due to ignorance of this important point that the press and others advocate the extension into the mofussil (by the opening up of

branches) of the type of commercial bank that does business in large cities. Banks specialize as do trades and other professions, and the commercial type of bank in a purely agricultural district would be completely out of its element and would be of less use than is the Chetty.

Short credit is the basis of the business of a commercial bank, whereas the basis of the business of an agricultural bank, in the present state of agriculture in Burma, must be long credit.

The writer would, therefore, recommend the type of a joint-stock agricultural mortgage bank as best suited to the needs of the districts. The following conditions should be observed in the case of such a bank:—

(1) It should of necessity be incorporated under the Indian Companies' Act so as to secure the advantage of trading with limited liability, while having, at the same time, all the safeguards of meetings, accounts, and audit.

(2) The management should be in very close touch with the people, and for this purpose it is necessary that it should know the language and understand the people and have some local influence.

(3) It should confine its operations to an area over which it can effectively exercise control.

(4) It should co-operate with co-operative credit societies and work in sympathy with them and with the Co-operative Central Bank.

(5) It should have an organization and a system ready to hand and easily workable, and it should be possible to demonstrate that the system is reasonably sound.

(6) It should take the fullest advantage of the work of the agricultural department and use its influence to improve husbandry and allocate funds for experimental purposes.

(7) While not making credit too facile, it should aim at the cheapening of credit and should attempt to bring down rates of interest to the level that members pay to their co-operative societies.

An incorporated mortgage bank, that owes its existence to private enterprise and complies with the above requisites, is an institution that, I think, deserves positive encouragement and support. It can not only do much towards relieving agricultural indebtedness and helping forward the best interests of the province, but it can also reach that large and not uninfluential class which either refuses to open its doors to co-operation or through some defect of character or idiosyncrasy of temperament fails to adapt itself to co-operative methods. It will supplement the work of the co-operative movement, and it is, therefore, entitled to similar consideration and support.

Government Assistance and Control.

We may now indicate the nature of Government assistance required to carry out these proposals and the nature of Government control.

Owing to the difficulties of raising capital, the best way to promote the establishment of such banks as have been indicated is for Government to provide a proportion of the capital, say, 50 per cent. of what is considered advisable or necessary, and for Government to be content with a guaranteed 5 per cent. dividend, and to hold all the preference rights, and to exercise its control by holding either a Government audit or such other audit as it may prescribe.

Such a scheme would not commit Government far. A bank on these lines could be opened in some district headquarters as an experiment, and, if the results are satisfactory, steps can be taken to start them in other districts. I do not think that Government should be represented on the board of such a bank, and it would obviously be undesirable for many reasons: there would really be no necessity as the safeguards would seem to be ample.

I am confident that such a bank would require small capital and that it would be quite easy to get all the funds it required from the public. It should not ordinarily be assisted by loans from Government, unless, in the particular district in which it operates, Government should decide to allow it to administer all agricultural loans and do away with the official administration of them.

Loans made by Government for such a purpose should be fully secured and should be repaid promptly once a year. If loans should be required from Government for any other purpose, a strong case should be made out, and, if granted, should be secured by debentures so as to afford Government absolute security.

Under this scheme each district bank will be an independent unit and will stand on its own merits. A proportion, say, one-fourth, of the capital should be locally subscribed, and as an illustration this bank would be willing to subscribe, in addition to a few founders' shares, a proportion equal to the locally subscribed capital and would undertake to raise locally the proportion of the needful capital.

It may, however, be stated that this bank owes nothing to Government assistance and has asked for none. It has attained its present development not without difficulty and not without encountering some prejudice; but it has received a substantial measure of support from the public, and it is satisfied that its achievement will continue to merit that support; and while the bank has discovered a field of enterprise that offers good investment, it is also helping to develop the agricultural resources of the province.

THE DAILY VARIATION IN THE COMPOSITION OF MILK.

BY

D. ANANDA RAO, B.Sc.,

Assistant Principal, Agricultural College and Research Institute, Coimbatore

EXPERIMENTS on rather an elaborate scale have been conducted on the composition of milk of some breeds of cows and buffalos by Drs. Leather and Mann and Mr. Meggitt. The subject of this paper is not an attempt at a work of similar nature, either in experimental detail or accuracy, but was merely instituted to see if any light could be thrown on the great variation that there is in milk which is purchased at the College Dairy, Coimbatore, from milkwomen of the neighbouring villages for the manufacture of butter. The writer laid his hands on the data referred to above only after the present experiment had been completed, so that, if the results happen to be similar, these help to emphasize, though in a modest way, the accuracy of the previous workers.

Although the College Farm possesses a mixed herd of its own, its main purpose is to supply pure milk to the residents of the Estate. In the manufacture of butter, some 200 lb. of buffalos' milk is required daily, and this is mainly obtained by purchasing milk brought to the counter by women from adjoining villages. The milk is daily tested by the lactometer only, and is paid for at so many pounds per rupee and not by the fat content. The lactometer readings are not very accurate, and yet the writer has often noticed from day to day a good deal of variation in the readings of milk brought by the same individual. There was neither the staff nor the time to test composite samples of milk periodically, and all that could be done was to test for fat by the Leffmann Beam method occasionally, whenever the milk sample raised one's suspicion, and

if it was below standard the individual was severely fined. This procedure for a time creates wholesome fear, and the woman brings unsuspicious milk until such time as she considers it safe enough to lapse into her old ways.

When the College closed for the Michaelmas vacation last year, some simple experiments were instituted to seek answers for the following problems : Is there any daily variation in the quality of milk in the same animal ? Does that variation differ in different animals like cows and buffalos ? What is likely to be the normal variation ? What is likely to be an abnormal variation and what are the causes ? Is there any relation between quantity and quality of milk ?

The experiment consisted in taking milk samples from (*a*) a dairy cow, (*b*) a dairy buffalo, (*c*) an outside buffalo whose owner was suspected of bringing adulterated milk, and (*d*) the average mixed purchased milk ; and testing them for fat *daily* for a number of weeks. The milk from (*c*) was always carefully taken without in the least exciting the individual's suspicions, so that she was allowed to bring as she liked without let or hindrance.

The results from the morning's milk are tabulated below :—

Date	(*a*) Milk from single cow, College herd			(*b*) Milk from single buffalo, College herd			(*c*) Milk from single buffalo (outside)			(*d*) Average of purchased buffalo milk		
	Percentage of fat	Yield		Percentage of fat	Yield		Percentage of fat	Quantity bought		Percentage of fat	Total quantity bought	
		lb.	oz.		lb.	oz.		lb.	oz.		lb.	oz.
September ... 5	2·6	3	4	7 0	4	8	7·3	6	4	7·0	204	0
,, .. 6	2·3	3	0	7·2	4	0	6·9	6	0	8·0	207	0
,, ... 7	3·0	3	12	7·5	4	8	9·0	5	4	7·4	207	0
,, ... 8	3·1	3	0	7·5	4	0	8·3	6	8	7·3	189	12
,, ... 9	3·5	4	0	8·3	4	4	7·2	5	12	7·0	201	0
,, ... 10	3·9	3	4	7·8	4	8	8·5	5	8	7·5	195	0
,, ... 11	3 0	3	8	7·8	4	4	8·5	5	12	7·0	203	4
,, ... 12	3·7	3	0	7·7	5	0	8·2	5	8	6·9	205	4
,, ... 13	3·4	3	12	7·8	5	0	6·8	5	4	7·4	209	12
,, ... 14	3·6	3	8	7·4	4	8	6·2	7	0	6·8	209	4
,, ... 15	3·6	4	8	7·5	4	8	4·8	7	12	6·7	210	0

Date		(a)			(b)			(c)			(d)		
		Milk from single cow, College herd			Milk from single buffalo, College herd			Milk from single buffalo (outside)			Average of purchased buffalo milk		
		Percentage of fat	Yield		Percentage of fat	Yield		Percentage of fat	Quantity bought		Percentage of fat	Total quantity bought	
			lb.	oz		lb.	oz.		lb.	oz.		lb.	oz.
September	16	4·1	2	12	7·0	4	8	6·0	7	8	6 7	202	8
,,	17	3 2	3	0	6 9	4	12	6·8	5	4	7·0	164	12
,,	18	3·6	2	12	7·4	4	8	6·2	5	0	6·7	163	8
,,	19	2·4	3	4	8·0	4	0	6·0	5	0	6·7	178	4
,,	20	2·6	3	4	8·1	4	4	4·7	5	0	6·9	153	8
,,	21	3·3	3	12	7·3	4	0	6·0	5	0	6·9	177	4
,,	22	3 9	4	0	7·8	4	0	5·2	5	0	7·0	174	4
,,	23	3 4	3	4	7·3	4	0	6·6	5	8	6 8	175	0
,,	24	3·2	3	12	7 4	4	4	6 4	5	8	6·7	175	0
,,	25	3·6	3	0	7 6	4	4	6 0	4	12	7·2	155	0
,,	26	2 9	3	0	6 9	4	0	5·8	4	8	6·7	163	12
,,	27	2 9	3	12	7·3	4	8	5·6	5	8	6·9	155	0
,,	28	3·7	3	8	7·8	3	8	5 4	5	12	6 9	173	4
,,	29	3·3	3	12	7·5	4	4	5 5	6	12	6 9	183	8
,,	30	3·1	3	0	8·0	4	0	6 0	6	12	6·6	173	12
October	1	3·3	4	0	7·5	3	8						
,,	2	3·4	3	8	8·1	4	0						
,,	3	3·2	3	0	7 7	4	8						
,,	4	4·0	3	8	7 5	4	4						
,,	5	3·7	3	0	8·1	4	4						
,,	6	3·1	3	0	7·4	4	0						
,,	7	3·8	2	12	7·8	3	4						
,,	8	3·2	3	4	6·8	3	12						
,,	9	3·1	3	4	7·3	4	0						
,,	10	3 9	3	8	7·1	3	4						
,,	11	3·3	2	12	7·4	3	0						
,,	12	3·2	3	4	7·0	3	12						
,,	13	3·3	2	8	7 0	3	12						
,,	14	3·1	3	0	8·0	3	0						
,,	15	3 7	3	0	6·8	4	0						

The results are graphically described in Chart I. It is very clear from the above figures that, whether cow or buffalo, the variation in fat in daily milk is evident. This is mainly due to the Indian practice of allowing the calf to suckle before and after milking, and the amount left by the milkman in consequence. The food might also influence the daily variation, but the dairy herd received throughout the experiment a definite ration of concentrated food consisting of cotton-seed cake, groundnut cake, and *dholl* (*Cajanus indicus*) husk together with a uniform quantity of green fodder, chiefly consisting of either one or more of fodders like green grass, Guinea-grass, and fodder *Sorghum*. The herd is taken out to

CHART I.
PERCENTAGE VARIATION IN FAT.

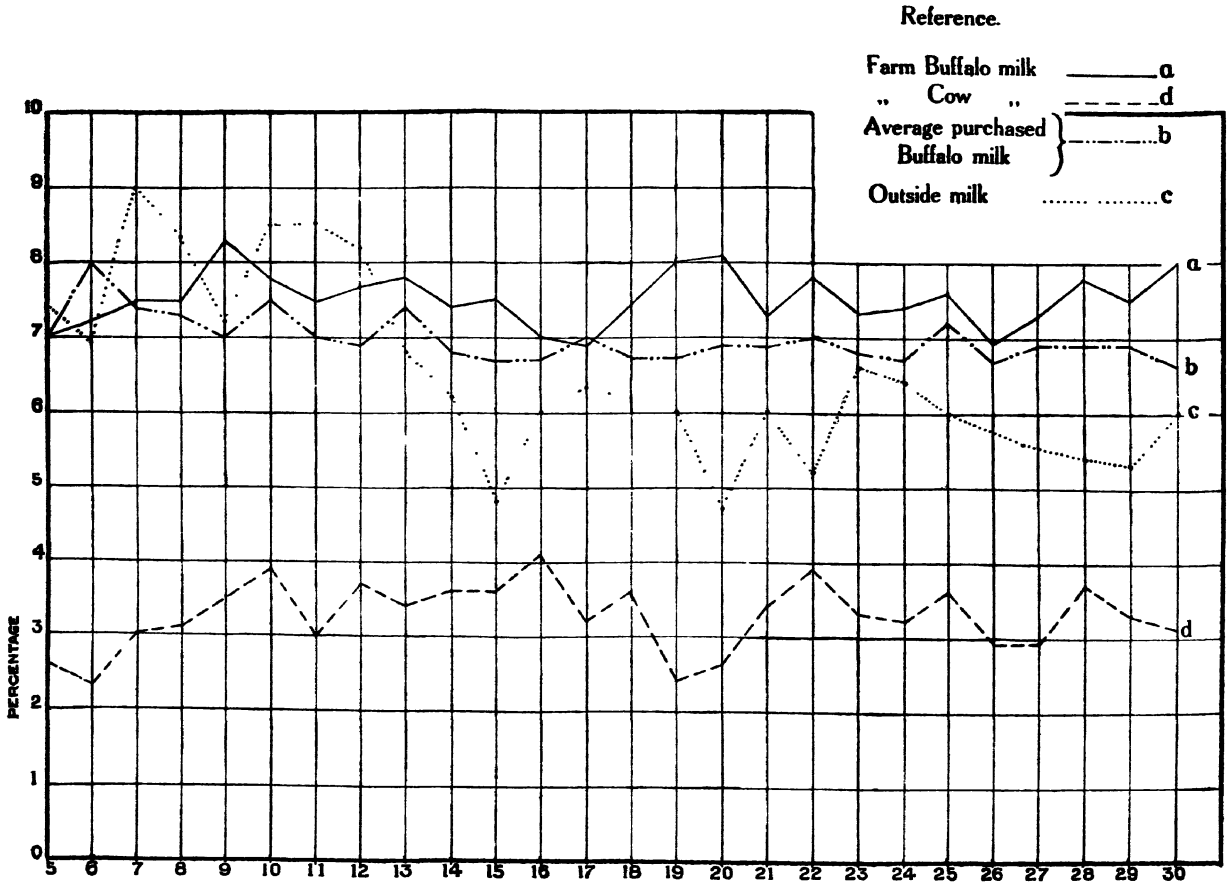
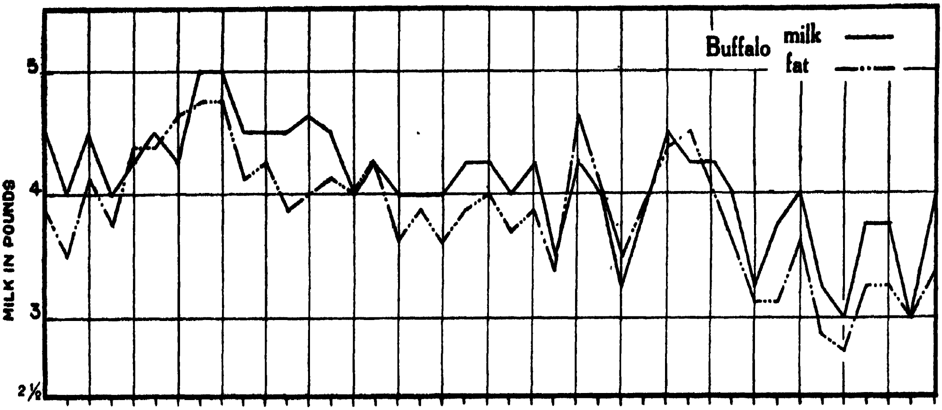
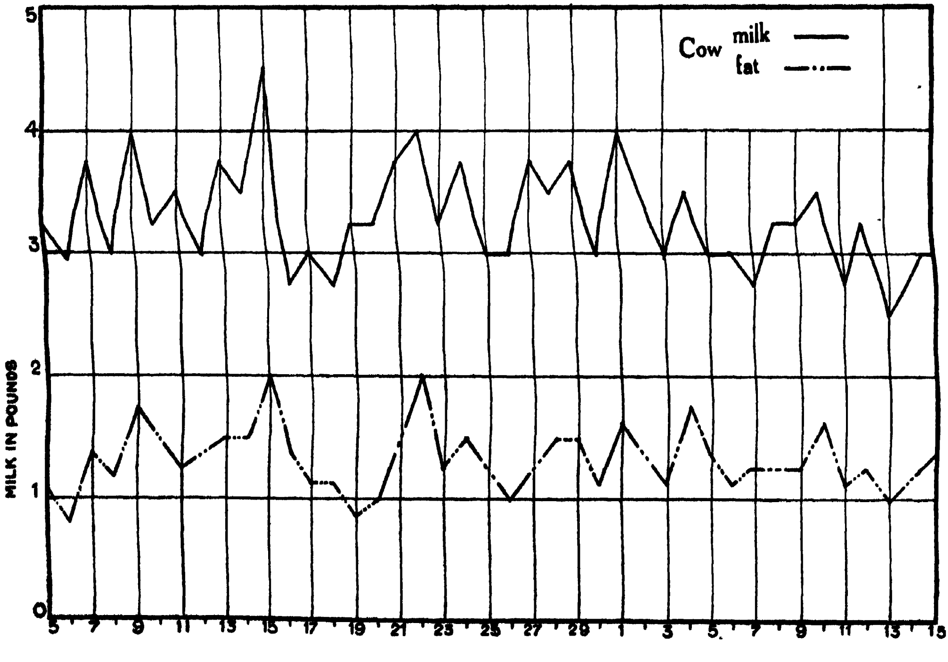


CHART II.

RELATION BETWEEN TOTAL AMOUNT OF FAT CONTENT AND TOTAL AMOUNT OF MILK.

8 divisions = 1 lb. of milk.
100 ,, = 1 lb. of fat.





graze in the day, but at this time of the year there is not very much bite on the land. The food given could not have influenced the variation so much either in quality or quantity. While there is such variation to be found in the individual cow's and buffalo's milk, the variation is very much less in the case of the average mixed purchased milk. A glance at the graph will make it very clear. It also points out the tremendous variation that there is in the milk purchased from the woman. It varies from 9 to 4·7 per cent., or there is a difference of 4·3 per cent. between extremes, while the dairy cow and buffalo show an extreme variation of 1·8 per cent. and 1·5 per cent. respectively. The average milk, however, shows a variation of 1·4 per cent. only. The variation in daily fat content is more marked in the cow than in the buffalo. In other words, the buffalo is the steadier one of the two. As far as this experiment goes, it must be assumed that the extraordinary variation of 4·3 per cent. in the buffalo milk purchased from outside is not due to natural causes. Knowing her propensity for admixture of milk, it may be safely assumed that the woman had intefered with the purity of the milk, either by the addition of water or by letting the milk stand for a while and removing the top milk which contains more fat; she may have perhaps taken recourse to both the methods.

The second part of the experiment was to see if any relation exists between the quantity and quality of milk that a cow or buffalo gives. This is represented in the form of a graph (Chart II). The two top curves represent the quantity of milk given by the buffalo and the total weight of the fat present in the milk obtained each day respectively. To make it clear, take the 5th of September (*vide* table above). The buffalo gave 4 lb. and 8 oz. of milk, which had 7 per cent. fat in it : so that 4½ lb. contained 0·31 lb. fat. This is what is represented in the curve. The lower ones indicate the same for the cow. In the majority of instances, when the secretion of milk increased, the fat content also increased, both in the case of the buffalo and the cow, but specially so in the former. Another point that is brought to evidence is that, although there is a deal of variation in the quantity of milk from day to day, the fat content in that quantity is fairly constant.

Selected Articles.

THE EFFECT OF ONE PLANT ON ANOTHER.*

BY

SPENCER PICKERING.

THIS paper will be read with interest in India in view of the very early attention which was called to the same phenomenon by the late Mr. F. Fletcher, Deputy Director of Agriculture, Bombay, in *Memoirs of the Department of Agriculture in India, Botanical Series*, vol. II, no. 3, 1908.—[EDITOR.]

FIG. 3 (*see* next page) shows a pot with two mustard plants growing in earth, on the surface of which rested a perforated tray with five inches of earth in it; through this all the water given to the plants percolated. The tray has been removed so as to be more clearly visible in the photograph. The presence of such a tray makes practically no difference in the behaviour of the plants in the pot below. Figs. 1 and 2 show a like arrangement,[1] but with a crop of mustard growing in the trays: in one case (Fig. 1) the effect has been to reduce the plants in the pot to one-hundredth of their normal size; in the other (Fig. 2) there has been no effect. The only difference in the two cases is that in Fig. 1 the washings from the surface growth were allowed to reach the plants in the pot (though the penetration of any roots through the perforations of the trays was prevented by a layer of very fine metal gauze at the bottoms of the trays), whilst, in the other (Fig. 2), no washings passed, the holes in the trays

* Reprinted from the *Annals of Botany*, vol. XXXI, no. CXXII.

[1] In Fig. 2 there appears to be only one plant: this is due to a fault in the photograph.

having been blocked, and such water as the plants required was given to them direct. The conclusion is obvious: the leachings from the plants growing in the trays must contain something which is toxic to other plant-growth.

Such a very simple experiment must definitely settle the question of toxin production, and should have been made long ago,[1] but as a matter of fact it comes only as the (at present) final step in a series which originated in 1895 in observations on the effect of grass on fruit-trees. As so often happens, we start with the more complex problems, and only gradually work down to the simpler ones.

FIG. 1. FIG. 2. FIG. 3

It has now been established with a reasonable amount of certainty that the deleterious effect of one growing plant on another is a general phenomenon. By means chiefly of pot experiments

[1] The details of this, and many of the experiments alluded to below, have not yet been published: a description of the other work on the subject will be found in the Third, Thirteenth, and Fourteenth Reports of the Woburn Experimental Fruit Farm, 1903, 1911, and 1914.

such as those indicated above, the following plants have been found susceptible to such influence: apples, pears, plums, cherries, six kinds of forest trees, mustard, tobacco, tomatoes, barley, clover, and two varieties of grasses, whilst the plants exercising this baleful influence have been apple seedlings, mustard, tobacco, tomatoes, two varieties of clover, and sixteen varieties of grasses. In no case have negative results been obtained. The extent of the effect varies very greatly: in pot experiments the maximum reduction in growth of the plants affected has been 97 per cent., the minimum 6 per cent., whilst in field experiments with trees the effect may vary from a small quantity up to that sufficient to cause the death of the tree. The average effect in pot experiments may be roughly placed at a reduction of one-half to two-thirds of the normal growth of the plant, but no sufficient evidence has yet been obtained to justify the conclusion that any particular kinds of plants are more susceptible than others, or that any particular surface crop is more toxic than another; that such differences exist is highly probable, but all the variations observed so far may be explained by the greater or lesser vigour of the plants in the particular experiments in question. Similarly as regards the effect of grass on fruit-trees, though the extent of it varies very greatly, and in many soils is certainly small, we must hesitate to attribute this to any specific properties of the soils in question; for when soils from different localities (including those from places where the grass effect is small) have been examined in pot experiments, they have all given very similar results; and this applies equally to cases where pure sand, with the addition of artificial nutrients, has been taken as the medium of growth.

In searching for an explanation of the effect of grass on trees, various possibilities suggested themselves, and these were excluded one by one, till the only possibility left was that of the formation of some deleterious substance by the growing grass. It would be impossible in this short communication to give any account of all the suggestions which were negatived, but these included the robbing of the tree of necessary moisture and food by the grass, alterations in the temperature, alkalinity or physical conditions of the soil, and alterations in its carbon dioxide and bacterial contents, the

exclusion of all which suggestions is embraced in experiments such as those mentioned above, where the grass or other crop is grown in a separate vessel, merely resting on the surface of the ground, without any possibility of it extracting anything from the soil in which the plant affected is growing.

From the outset the behaviour of trees in grassed land suggested the action of some toxin : not only is the growth arrested, but a peculiar alteration in the colouring of the bark, leaves, and fruit occurs, unlike that attending other forms of ill-treatment : indeed, the high colour developed by fruit under grass is, in some cases, so great, that expert fruit-growers have been unable to correctly name the varieties after being affected, and if this action of grass could be limited, and suitably adjusted to every tree, it would prove beneficial from the point of view of the fruit-grower, if not from that of the tree itself, especially as a limited check to the growth of a tree generally results in heavy cropping. The extent of the grass action which brings about these notable colour changes is very small, for they are apparent in cases of trees weighing about two hundredweight when only three to six ounces of their roots extended into grassed ground. Such an effect is in itself strongly suggestive of toxic action.

To some agricultural chemists the mention of a toxin as being formed in the soil by a growing plant is as a red rag to a bull, chiefly, perhaps, because it conjures up the picture of the plant ejecting some virulent poison ; but though the excretion of toxin from the roots is possible, there is no need for imagining such an occurrence : all plants in growing leave much root-detritus in the soil, and such disjecta may account for toxic properties, just as well as ejecta. That some forms of organic matter may be highly poisonous to plant-life has been established : soil which has been heated to 125° is very toxic, and there is evidence that toxicity may be produced in it by heating to much lower temperatures (*Journal of Agricultural Science*, iii, 277). In the case of heated soils, the chemical changes are complicated by changes in bacterial characters ; this may or may not be the case with soil which is growing crops ; but there is one feature in common between the two, namely, that in both cases the toxin is easily

oxidized, and that after oxidation, it acts as a plant nutrient, increasing the fertility of the soil. When in pot experiments such as those mentioned, the leachings from the crop in the trays are kept exposed to the air for about twenty-four hours before being given to the plant, their toxic property is found to have entirely disappeared, and in some cases, indeed, they act beneficially : even a two-inch layer of pumice-stone interposed between the tray and the earth in the pot will admit of sufficient oxidation for a reduction in the toxic effect to be discernible.

A reversal of the effect of grass may also be recognized in field experiments, for in a case where apple-trees were planted and kept clear from grass to a distance of 3 feet from the stems, the trees flourished better at first than those without any grass near them (and, of course, much better than those which had been entirely grassed). But as they grew and their roots approached the grassed ground, the toxin affected them before it had time to become oxidized, and they began to suffer. Though there are other reasons why land under grass gradually becomes more fertile, the accumulation of the oxidized products of the toxin must constitute an important factor in this enrichment. In certain experiments with apple-trees it was found that soil which had been under grass for ten years induced double as much growth as similar soil which had been under tillage, though when the turf was replaced on the soil, the trees showed all the bad effects of grass.

From the general character of the action of one crop on another, it follows that the tables may be turned on the grass, and, even in pot experiments, it has been proved that grass in the pots will be adversely affected by apple seedlings in the trays. In practice, of course, it is known that grass and other surface crops are adversely affected by trees. This is generally attributed to the shading effect, and to the robbing of the soil of its nourishment. Doubtless the shading produces bad results in many cases, but it may be questioned whether any serious robbing of the soil occurs, for there is good evidence for believing that ground under trees, even when worked regularly for timber, increases in fertility, just as does ground under grass. At any rate, it has been found that a surface crop may

suffer from trees above it, even in cases where there certainly has been an increase in fertility, and where, also, the shading effect is inoperative so that the damage to the crop can only be attributed to the toxic action of the trees. Thus, a quarter of an acre of land, over which some fifteen apple-trees, twenty years of age, were distributed, was planted uniformly with Brussels sprouts : those under the trees suffered to the extent of 48 per cent. in their growth ; but there were patches in the ground where trees had been growing until the preceding winter, when they had been cut down, leaving the roots undisturbed in the soil, and in these patches the sprouts did better than elsewhere to the extent of 12 per cent. In other parts of the ground canvas screens had been erected, at a height of 6 feet above the surface, to simulate, and even exaggerate, the shading of the trees, and under these the sprouts gave exactly the same values as on the unshaded ground. Thus, the trees themselves materially injured the crop, though the soil under the trees was more fertile than elsewhere, and though the shading was inoperative.

Though differences in the toxicity and in the susceptibility of different plants may be overshadowed by differences due to other causes, it is highly probable, as has already been mentioned, that such differences do exist. The only case of differences of a positive character noticed at present in our experiments, is that the effect of a plant on plants of its own kind is generally greater than that on plants of another kind. This may be fallacious ; but, certainly, a plant affects its own kind just as much as any other kind ; and hence we must conclude that the toxin formed by any individual plant will affect that individual itself. This has been proved by growing plants in pots divided into compartments, so that there was no root interference, and comparing these with other plants grown in similar pots not so divided : in the former case each plant will be affected only by the toxin produced by itself, in the latter it is affected partially by its own toxin, and partially by that of its neighbour, but the amount per plant must be the same in both cases, and, as a matter of fact, the plants all gave the same results, except for a slight advantage in favour of those undivided pots, due to conditions which can be easily specified.

When a stronger and weaker plant, or an older and younger one, are growing side by side, we find that the latter rarely picks up, and generally gets more and more behind its stronger brother. This cannot be due to the stronger one monopolizing the food-supply ; for if it exhausted this supply both plants would suffer at the same time, and, till that supply is exhausted, both would flourish equally. The inadequacy of any such explanation is demonstrated by taking a pot of soil capable of growing, say, six plants, sowing the seed for three of them first, and that for the other three a certain number of days later. In the case of mustard, when the difference of date is only four days, it is found that, at the end of growth, some two or three months later, the last sown plants are 60 to 70 per cent. smaller than the others. It is evident that three four-day-old seedlings could not have exhausted the nourishment in 7½ kilos. of rich soil so far as to leave insufficient food for three other seedlings ; nor can a difference in age of four days in a total life of several months account for such a difference in the weights of the plants. But the results become clear if we take into account the toxic effect of one plant on the other, for the later planted individuals have to start growth under toxic conditions which were absent in the case of those first planted, and throughout their existence their inferiority in size will make them suffer more than their stronger brethren, though the actual amount of toxin in the soil is the same for all. Yet it is found that they are not altogether without their revenge, for the toxin formed by them affects to a certain extent the older plants, and this effect may be traced, even when the feebler plants are only about one-tenth the size of stronger ones. The importance in practice of having seed which will germinate uniformly at the same time, or in having plants of uniform growth in a bed, is demonstrated by these experiments ; for a difference of only four days in the germination of one-half of the seeds in the case of mustard reduces the total weight of the whole crop eventually obtained by as much as 20 per cent.

The divided pots have been utilized to ascertain what the effect of crowding in a plantation is when there is no root-interference. In appearance the results were remarkable for with mustard and

tobacco plants at distances of 4, 6, and 9 inches apart, the plants were considerably smaller as the distances between them were greater, the deficiency in their height extending up to 30 and even 50 per cent., and they appeared to be in every way inferior. But these appearances were entirely misleading, for it was found that the weights of the plants were the same at whatever distance they were planted and at whatever age they were lifted ; moreover, this equality held good throughout the plantation, even including the outermost rows : thus, interference of the above-ground portions of plants does not affect the amount of growth, but only the quality of that growth.

The results are very different, however, when there is root-interference, as when a number of plants are grown together in one pot, or in one plot in the field ; and when the crowding attains to a certain magnitude, the limiting factor is the amount of soil available for each plant : the result of which is that the weights of the plants are inversely proportional to the bulk of soil available (which with soil of uniform depth is synonymous with the area), or, in other words, the total plant-growth is the same, whatever be the number of plants. Thus, in pots containing 7½ kilos. of rich soil the total crop was the same with from sixty-four down to sixteen mustard plants (the latter number representing plants at a distance of 1·8 inches apart), or with from sixteen down almost to one plant of tobacco ; whilst in unmanured ground in the field, the equality holds good within a wider range, even to plantations with more than 6 inches between the plants in the case of mustard. At the same time also, the outside rows of plants are very much superior to the inner plants.

This latter superiority is one which is continually noticed in field experiments, though the reverse, judging by mere appearances, sometimes obtains. Whether, when the outside plants appear the worse, they are so in reality, may be doubted ; at any rate, in all the cases which have been investigated by weighing, it is a superiority which has existed. But appearances would never have led to a correct estimate of the magnitude of this superiority, for these outside plants are often 100 to 200 per cent. greater in weight than

the inside ones. The row next to the outside one generally shows some superiority, but the effect of an external position extends to only about 6 inches from the edge of the plot.

The extra vigour of the outside plants is generally attributed to the extra manure which they have to draw upon ; but another factor must now be reckoned with, in the extra facility offered for the oxidation of the toxin at the edge of the plot ; and this appears to be an important factor. The question is being investigated on three lines ; manure beyond a certain limit does not benefit, and even injures a plant ; if, therefore, in a plot where the manure has already attained such a limit, we still find that the outside plants show a superiority, this cannot be due to any further surplus of manure. Such a superiority, we find, still exists in ground manured with 100 tons of dung to the acre, and the superiority is little less, if less at all, than in unmanured ground. But these experiments require repetition and extension before definite conclusions can be drawn from them.

THE TREATMENT OF FUNGOID DISEASES ON ESTATES.*

BY

R. D. ANSTEAD, M.A.,

Deputy Director of Agriculture, Planting Districts.

I HAVE been much struck by the contrast between different planting districts of Southern India in the way in which they attack the problem of fungoid pests. In some districts, and on some estates, a great deal of careful attention is paid to this problem, and a considerable amount of money is spent on it; while in others hardly anything is done, and what little attempt is made to control diseases is made in a half-hearted manner and at a minimum of expenditure.

I do not think that the importance of fungoid pests is sufficiently realized, or the latter attitude would not be so often adopted. The loss of a few tea bushes or a rubber tree or two may not appear at first sight of any great importance, but I will try and show you just what it means.

Take the case of young tea, attacked as it so often is by a root disease. I was informed by a tea planter, whose estate I was inspecting a short time ago, that each tea bush when three years old had cost only two annas; that was the cost of putting it there when the value of the land, clearing, seed, planting, weeding, etc., were all reckoned up. This is not the actual value of a bush, perhaps, because it also has a capital value as an asset; but we will accept this figure as being one of actual value. This same planter had a bad attack of root disease in his three-year-old clearings and was

* A lecture delivered at the annual meeting of the United Planters' Association of Southern India, 1917

losing bushes up to 10 per cent. The bushes were planted 4′ by 3½′ or 3,000 to the acre, so the loss was 300 bushes per acre. The value of these is, on our basis of 2 annas per plant, Rs. 37-8. How many planters would be willing to spend this sum per acre on tackling the problem of root disease? Yet it would obviously pay to do so, could the bushes be saved, or even a proportion of them, for remember that the dead plants have to be replaced which will take another three years, and cost, say, one anna each this time, or Rs. 18-12 per acre, and at the end of six years no return has been got from this total expenditure of Rs. 56-4 per acre.

Let us next take the case of coffee attacked by black rot. Last year an interesting experiment was carried out in Coorg to try and ascertain the actual loss of crop caused by this disease. I will not here go into details of the experiment; suffice it to say that a few trees had mats spread under them, some were sprayed and some were left alone, and the berries which fell off were picked up daily and counted and weighed, and the crop which matured on each group of trees was picked and weighed separately. The result was that we found that, in a year when the disease was particularly light, half a cwt. of crop per acre was destroyed by the fungus and could be saved by spraying. This may safely be put at Rs. 25 an acre, yet how many coffee planters are willing to spend that amount on preventive measures?

When we turn to rubber we have a still more valuable asset in each tree. What is the value of a full-grown rubber tree as it stands in the field ready to tap? I have recently seen it put at Rs. 15. However, say, an acre containing 120 trees cost £30 to bring into bearing, not an outside figure; each tree has cost a little over 5*s*. to put there, though its actual capital value is more than that. Yet many rubber estates are unwilling to spend Rs. 25 per acre on the control of fungoid pests, the value of six or seven trees. The Government Mycologist has told you that this expenditure would, in all probability, prevent the trees being attacked by *Phytophthora*. When the trees are thinned out to 80 per acre, a position which must rapidly obtain in South India, the loss of a single tree, or the fact that a tree is thrown out of tapping for six months or more, due to

the attack of canker or some other bark disease, will become of immense importance.

I maintain that we can easily afford to spend much more than we do at present on the treatment of fungoid diseases and that it would pay us handsomely to do so.

Thus on a certain estate in the Wynaad, brown blight (*Colletotrichum Camelliæ*) attacked a big tea nursery very badly, 175,000 plants were endangered, and the attack was so bad that orders were received by the manager to destroy it and start again. Instead of this, however, it was treated carefully and thoroughly. All the diseased leaves were picked off and burned. All the dead and dying plants were removed and all the fallen leaves on the ground collected, and the beds were treated with lime. Light was admitted and watering was carefully done only when necessary. The nurseries were then sprayed with Bordeaux Mixture twice. The consequence was that the nursery was saved and the plants put out in the field. When the saving is considered (the cost of the seed and the nursery, the fact that, had it been destroyed as at first proposed, the land waiting for the plants would have lain idle for at least a year and had to be re-cleaned and prepared), it will be seen that by careful attention and the expenditure of a few rupees promptly—100 at the outside—a very large sum was saved.

On another estate a five-acre patch of old tea, particularly badly attacked, left the bushes almost leafless, except for a small spurious new growth on the top of the branches. Other parts gave one the idea that a fire had run through the field. The new wood on all badly attacked bushes was whippy and wiry and could not be pruned on to, thus necessitating collar pruning. When this was done the new suckers were attacked and killed which caused the ultimate death of the bush.

This area was put under special treatment ; it was cultivated frequently and kept clean to get rid of all fallen leaves covered with spores so as to avoid re-infection. It was limed and manured with basic slag, and the field was sprayed with Bordeaux Mixture. At the same time all the diseased leaves were picked off, collected, and burned, this work being constantly and well done. In fact 17,269 lb.

of leaf were removed. This treatment was expensive but thorough, and as well carried out as a preventive method could be carried out. What was the result? In six months the healthy foliage had been restored and the ground was completely covered where before it was exposed between the rows of bushes, the character of the wood had changed, and the bushes were growing rapidly. The disease was still present it is true; it is doubtful whether any method yet devised will completely stamp out a fungoid disease once it has got hold of a crop grown over an extended area, but there was not more on this field than on the rest of the estate.

The question is, Was it worth the trouble and money expended, was it a sound practical policy of the planter concerned to carry out our recommendations thoroughly and not stint the money for doing so? I leave you to answer that question, and in doing so just reckon up the value of five acres of old tea which would have been lost and would have had to be replanted and brought into bearing again, and set against it the fact that the operations described above cost Rs. 50 per acre.

On the same estate this disease was tackled with a great deal of success by collecting the diseased leaves; 40,000 lb. of leaf were brought in during the year and burned. This method of control was not so expensive as it might appear at first sight, because children and others were employed in this work who would not otherwise have worked on the estate, and a cash payment was made per given weight of leaf collected. Where labour is available, this is undoubtedly an excellent means of controlling this disease, as the leaves are picked off and destroyed before the spores are produced and distributed from them, and it serves as an excellent example of how an important disease, which is a menace to the tea industry, may be controlled if money is freely spent on it.

I will now indicate in the case of a few diseases how the methods at present adopted on many estates could be improved if a little more money were spent.

Take the case of root diseases first of all, fungi which attack all our crops and cause an immense amount of loss in the course of a few years. I do not wish at the moment to discuss possible methods

of preventing the occurrence of these diseases, such as the removal of stumps of jungle trees known to induce the fungi before ever the land is planted up, the careful removal of stumps and roots of shade trees which may be cut out, and so on ; but I wish to point out how the actual field treatment of dead plants may be improved. So often a root disease patch spreads and takes an annual toll of the plants around it. This can be prevented by careful work, provided that money is spent on it. In the first place the dead tea or coffee bush, or whatever it may be, should be removed as soon after death as possible. A big pit should be made and all the dead roots and decaying wood taken out and collected and burned. To do this thoroughly, it is worth while passing all the soil from the pit through a sieve. Somewhere near the dead plant an old jungle stump will be found in most cases and this is, in all probability, the cause of the trouble. This should be removed at the same time with all its dead roots as far as they can be traced. The soil should next be thoroughly mixed with lime in liberal proportions in order to correct acidity and hasten the decomposition of infected organic matter. It should then be heaped up and exposed to the sun for a few months and it may afterwards be safely replanted. In the case of bad attacks where a group of bushes have died, it may be necessary to put in isolation trenches. These trenches should be taken completely round the patch and should not be bridged by logs or roots, and the soil taken from them, which may possibly be infected, should be thrown into the patch and not scattered among the surrounding cultivation to infect it. Attention to all these details, which no doubt add to the cost, just means this that the disease is controlled and, in a large number of cases, cured, and a supply will grow instead of dying out again in a few years leaving all the work to be done over again : and for this reason the extra trouble and cost are worth while.

One more example. Rubber diseases often necessitate the removal of a patch of bark and wood. In the case of canker, for instance, the diseased patch must be cut out and the wound thus made tarred. This work is more often than not done very badly. In the first place it is necessary to remove all the diseased tissue and healthy tissue for at least an inch round it ; that is to say, the

diseased spot must be followed up and cut out till healthy tissue is found for at least an inch all around it. The material removed should be collected and burned ; it is full of fungus and probably capable of producing spores and infecting other trees. Consequently it is worth while spreading a bag at the foot of the tree to make sure that all the excised material is collected. Next tar is to be applied to the wound, but it should not be applied to the healthy tissue. Consequently it should be put on with a proper brush and not daubed all over the wound and the surrounding stem with the hand or a piece of fibre, or something of that sort. Again the tar should be of the right consistency and not too thick as it often is. A very little tar is necessary, but I have seen trees in many cases left in a horrible mess of thick tar which undoubtedly burns the young bark and prolongs the time necessary for a wound thus maltreated to heal over, and moreover makes it most difficult to inspect the work later on to see if there is any sign of the recurrence of the disease. Thirdly, such treated patches should be inspected from time to time to see that boring insects have not got in, and they will occasionally need another coat of tar. Lastly, a most important point hardly ever attended to, the chisels, knives, etc., used for removing a patch of disease, canker, pink disease, or whatever it may be, are infected, and, if used to make a trial inspection of another tree, may inoculate it with the disease. I have little doubt that pink disease (*Corticium salmonicolor*) is often spread in this way, and I know that line canker (*Phytophthora*) is spread from tree to tree by means of the tapping knives. Consequently as soon as a case has been treated all the knives, etc., should be disinfected before they are used on the next tree, and it would be well worth while conducting experiments to see whether tapping knives could not be carried from tree to tree immersed in some disinfectant such as a weak solution of formalin.

One could go on giving examples of how methods of treatment of disease could be improved if a little more time and money were devoted to them, but those I have already given will suffice. They lead me to the main point which I wish to emphasize, namely, the absolute necessity on each estate of a well-trained pest gang,

consisting of a *maistry* and a number of the most intelligent coolies who can be found, who should do nothing else but attend to diseases and treat each case well and thoroughly. The gang should be of such a size that it may get round the whole estate at least once a month. On a rubber estate especially each tree should be inspected carefully for disease at least once a month.

Supervision is of course necessary, and here I think there is room with advantage for an innovation. It is usually considered too expensive to employ a European assistant for supervising work on pests and diseases only ; even if one is appointed he is soon taken off to perform other duties. It always strikes me that there is too big a gap between the European assistant on a big estate and the field-writers, and I would suggest the employment of a man intermediate between them in standing and salary, a man who has had a scientific training, and who is capable of dealing intelligently with diseases and carrying out the remedies recommended by the scientific officers. Such a post might well be filled by an Indian trained at Coimbatore. Were such posts available the demand for men would soon be met. The advantages of having such a man on the estate would be many. He would be placed in charge of the pest gang and do nothing else but look after disease work. His training would ensure that he was capable of recognizing a disease when he saw it, and in its initial stage, and of carrying out carefully and intelligently the methods recommended for its control. He would be responsible for the keeping of spraying machinery in order, making up spray fluids properly, and he would generally supervise the work on pests and diseases.

One of the matters to be discussed at this meeting is the advisability of appointing a mycologist to study rubber diseases. If we had a mycologist, he would find such trained men on the estates an immense help. They would be capable of conducting experiments and carrying out investigations in the field and noting results with a trained mind, and, moreover, they would have time to devote to such experiments which no assistant or manager can be expected to have. This trained man would only deal, in the first place, with known diseases ; if he noticed a new disease, he would

report it and the aid of the mycologist could at once be obtained, and there would be a certain amount of reliable information about the disease, its extent, position, and so on to lay before him.

Let us consider how such a well organized pest gang under such supervision would work. On a rubber estate they would inspect each tree at least once a month and examine it critically for pink disease, canker, bark rot, etc., and treat it, if necessary, in the most approved way with the best tools and apparatus known, for it would naturally be an economy to give the gang the best possible known outfit. They would remove branches which had died back and dead fruit as a preventative against *Phytophthora*. They would notice the first signs of root disease and take the necessary precautions. They would paint trees with Bordeaux Mixture to protect them from pink disease ; they would attend to old wounds, re-tarring them if necessary, wounds on the tapping cut, and ensure that bark preservatives were being properly applied and collecting cups kept clean. Whenever no other work was available the gang might profitably be utilized for removing old stumps and on general estate sanitation work. I might here say that, when thinning out is done, it is absolutely necessary that the stumps of the rubber trees should be removed below ground-level if fungoid diseases are to be kept under control. It is not only fungi which cause root diseases which are to be feared, but also bark fungi which can live and propagate on such old stumps. In Ceylon *Ustulina* and other fungi have been found to develop on Hevea logs left lying in the field after thinning out.

On a tea estate the pest gang would inspect each field each month and attend to root disease cases. They would notice and deal at once with attacks of caterpillars which often do a considerable amount of harm before they are discovered by the pluckers. They would deal with leaf fungi, like brown blight and *Gleosporium*, and be in a position to notice at once when these were getting bad enough to warrant treatment, especially in clearings. They would inspect nurseries regularly and keep them sprayed against leaf diseases. They could also control the mosquito blight (*Helopeltis*) work and go over pruned areas to see that the bushes had been properly cut and cleaned, and

they would apply washes to clean the stems of *epiphytes*. Again when other work failed they could be employed to remove jungle stumps, especially those known to be likely to cause root disease.

On a coffee estate such a gang would be equally useful. They would deal with borer-infected trees rapidly, spray for scale insects, black rot, and leaf disease, and treat root diseases, seeing that isolation trenches were clean and open. They would also regularly inspect all the shade trees for scale insects and other pests.

The great advantage of such a system would be that diseases would be attended to immediately upon their first appearance and before they could make headway, a matter of the utmost importance when dealing with any disease. Too often is it the case that certain trees are known to be diseased, but they cannot be attended to for some time afterwards and their locality is not then accurately known. How often does it happen that I am taken to see a tree suffering from, say, canker, and after finding a writer, who finds a *maistry*, who finds a cooly, who wanders about for some time, the tree is at last found—and is not suffering from canker at all. This picture is not overdrawn, and it is an unsatisfactory position of affairs.

Under the system which I suggest the work would be well done under skilled supervision and from my observations there is room for a great deal of improvement in the way such work is done at present. It should be impossible for an estate which is attending to diseases properly to show me a number of trees dead of root disease. The utmost that should be possible is to show me the pest gang actually removing such trees.

Parasitic diseases are a serious matter in South India and are likely to become more so as time goes on. Especially is the matter of importance on rubber estates, where so many fungi can attack the bark, and every possible precaution should be taken to guard against such diseases and control them. *The India Rubber Journal* stated a little time ago that "it is as well that all the interests of our industry should bear this factor in mind. While we believe that the moist hot atmosphere prevailing in rubber areas will make it easy for parasitic fungi to spread, we are convinced that, *if proper*

precautions are taken, the damage done will be small. The rubber plantation industry has not yet realized the danger ahead, and it should be possible to ensure considerable sums of money from every one interested in plantation rubber to protect this magnificent national asset."

Are such sums of money forthcoming in South India ? At present, as someone remarked the other day, more is spent on the hoop iron put on the rubber chests than on the scientific department. The journal quoted above places the responsibility of any disease doing a large amount of harm in the future on the shoulders of the scientific department. Is this fair in our particular case ? Have the rubber planters of South India taken all the steps in their power to equip their scientific department with men and means to deal with diseases, or to ensure that the recommendations made by their department, such as it is, are carried out properly on the estates ? I venture to think not.

It is not only the rubber industry which is threatened by diseases. Tea and coffee are in the same danger. Coffee planters know what a disease can do, they have seen the effects of leaf disease (*Hemileia*) in Ceylon and green bug (*Coccus viride*) in the Nilgiris and Pulneys. Tea planters in the north have witnessed the effect of a leaf disease like blister blight, and some of us in South India have had an inkling of what a bad fungus attack on the leaves might mean when for some unexplained reason brown blight began to do damage over a limited area last year.

Now is the time before the trouble comes, as come it will one day be sure, to see to it that you have a properly equipped scientific department with staff and money to deal with it when it comes, and a properly equipped and staffed organization on the estates for carrying out the recommendations of that department.

COTTON-GROWING RESOURCES OF THE BRITISH EMPIRE.*

BY

J. ARTHUR HUTTON,

Chairman of the Council of the British Cotton-growing Association

During recent years it has been a matter of constant complaint with spinners that they find an ever-growing difficulty in obtaining suitable cotton for spinning yarn of good quality, and that year by year they have to pay a higher premium for the requisite quality of cotton. To-day they have to pay a premium of 1*d.* to 1½*d.* per pound for the same quality of cotton which could formerly be easily obtained in quantity for a premium of ¼*d.* to ½*d.* per pound over "Middling American." This rise in the premium or "basis" is very clearly shown in the relatively higher price which now has to be paid for Egyptian as compared with American. The following figures give the relative average prices for the twenty years prior to the war:—

Five years	Middling American	F. G. F. Egyptian	Difference or Premium
	d.	*d.*	*d.*
1894—1898	4·27	5·39	1·12
1899—1903	4·20	5·79	1·59
1904—1908	5·70	8·12	2·42
1909—1913	6·48	9·93	3·45

These figures show that the premium for Fully Good Fair Egyptian as compared with American has increased in the last fifteen years from 1⅛*d.* to nearly 3½*d.* per pound.

This demand for finer goods and consequently for high-class cotton will certainly grow in the future as it has done in the past, provided cotton of the requisite quality is available, and this is a question affecting Great Britain more than any other country.

* Reprinted from the *Empire Review*.

As previously pointed out, we have mainly been able to meet and defy the competition of the world by devoting ourselves to the production of goods of finer quality. Therefore year by year we require more and more high-class cotton to enable us to compete in foreign markets and to maintain and extend our export trade. If ample quantities of the requisite quality of cotton are not available, this export trade will certainly be most seriously injured, and may even disappear, with disastrous results to the whole country.

It is evident that not only does Lancashire require larger supplies of cotton, but also that this cotton must be of special quality, as otherwise it is almost useless. One, therefore, cannot resist the conclusion that it is the paramount duty of the Government to do all in their power to develop as rapidly as possible every district which is capable of growing high-class cottons, for on the success of these efforts depends the whole future, indeed the very existence, of our great cotton industry.

Enormous Yearly Output.

Those of us who are actively engaged in the cotton trade are so accustomed to thinking in terms of American and Egyptian cotton that we are apt to forget there are other cotton-producing countries. Probably few realize that even at the present time something like $5\frac{1}{2}$ million bales of cotton are produced every year in the British Empire. The following statistics show the area, the population, and present estimated production (in bales of 500 lb. each) of the principal British cotton-producing countries :—

Place of origin	Area in square miles	Population	Estimated production (Bales of 500 lb)
Extra Fine—			
West Indies	12,140	1,718,216	4,500
Long Staple—			
Egypt . ..	363,181	11,287,359	1,360,000
Sudan	984,520	3,000,000	16,000
Medium State—			
Uganda	121,437	2,893,494	32,000
Nyasaland and N.-E. Rhodesia	329,801	1,847,904	5,500
Nigeria	336,000	17,611,941	32,000
Short Staple—			
India . ..	1,802,657	315,156,396	4,000,000
TOTAL ..	3,949,736	353,515,310	5,450,000

THE INDIAN CROP.

At the first glance these figures are reassuring for we have a total production of nearly 5½ million bales, whereas the annual consumption of Lancashire is about 4 million bales. It would also appear that as far as area and population are concerned the Empire ought to be able to produce all the cotton that we require, and also a fair surplus for other countries. There are, however, several other factors to be taken into consideration. In the first place, India herself requires more than half of her crop, and she would justly resent any attempt on our part to rob her of the cotton on which her mills so largely depend. This, therefore, reduces the available quantity to 3½ million bales which is ½ million bales less than our consumption. Again, we have to consider the needs of our Allies, who shoulder to shoulder with us are fighting for the freedom of humanity. They also use a considerable quantity of Indian cotton, and nearly one-third of the Egyptian cotton is consumed by France, Russia, Italy, and America. Further, probably not more than 200,000 bales, at the very outside, of Indian cotton would be suitable to Lancashire's requirements. Nor, if we are wise, ought we to disregard the requirements of neutral countries, who, although they sincerely sympathize with us, are not in a position to tender us practical aid. Even if we were to take the extreme step of earmarking the present production of the Empire for our own needs, the total quantity available of suitable quality would not amount altogether to more than about 1¾ million bales, or rather less than half of our total requirements.

The question, therefore, faces us, Can the undoubted resources of the Empire be sufficiently developed to supply cotton of suitable quality and in sufficient quantity to satisfy the whole of our needs? This is the problem which led to the formation of the British Cotton-growing Association, and I think that a short account of the work carried on by this body will best enable my readers to decide whether the Empire can provide the cotton which we need to maintain and develop this wonderful industry.

Work of Cotton-growing Association.

One hears a great deal about developing the resources of the Empire. Unfortunately most of what is said is ill-informed and unpractical, and shows little knowledge of how we should set to work. It is, therefore, an immense advantage that a great deal of the spade-work has already been carried out by the Association, and they have not only proved where and how cotton can be grown, but also where it cannot be grown. The Association is, I believe, the only body which has set to work in a business-like manner to carry into effect what other people merely talk about. It is very much to the credit of Lancashire that we can show so good an example of practical politics, and we cannot sufficiently thank those self-sacrificing individuals, both employers and operatives, who voluntarily raised £500,000 of capital with very little prospect of a direct return in the form of dividends. They set an example of true patriotism, and it is also much to their credit that fourteen years ago they were able to realize the danger of the position, which is perhaps only to-day just beginning to come home to their slower-witted fellow-countrymen. It is a good exemplification of the old saying: "What Lancashire thinks to-day England will say to-morrow."

The problem the Association set out to solve was whether the Empire could produce sufficient cotton to keep our mills running full time, and so bring prosperity and happiness to the millions of people of this country who depend on the cotton trade for their daily bread.

It was a rough proposition, for to all of us it was entirely new business, and beyond being good judges of cotton none of us had any technical knowledge of the question. Everything had to be learnt from the beginning, and, as was only to be expected, we made a good many mistakes. I can, however, say this, that the council have never been afraid of owning up mistakes. The crop grown under our auspices is expected this year to amount to 100,000 bales, which will be worth over £2,500,000. To build up an annual turnover of £2,500,000

in fourteen years is no small achievement, and especially so when one takes into consideration the countless difficulties which had to be overcome. Undoubtedly 100,000 bales is a small matter in comparison with the 4,000,000 bales which are required every year to keep our mills running full time. We have, however, made a beginning, and we have acquired experience which will be invaluable if a determined effort is to be made to increase the cotton production of the Empire.

THE WORLD'S COTTON SHORTAGE.*

BY

PROF. JOHN A. TODD.

FOR many months, running even into years, certain so-called pessimists have been dinning into the ears of the cotton trade the danger of the shortage of cotton becoming a really serious scarcity. A year ago the price was just over 8*d.* per lb. for American Middling, and those, who prophesied that the price might go to a shilling, were hardly taken seriously. But "Shilling Cotton" came in November, and was received with little more than a shrug. Margins were better than ever, and although there was a good deal of talk, it was very hard to get the trade to tackle the question seriously. The high prices soon passed; and, the wish being father to the thought, the trade concluded they had seen the last of them, and went about their business undisturbed.

Such complacency was in a way justified by the logic of the situation. The root cause of the comparative scarcity, which in two years had apparently eaten up the enormous surplus of the record crop of 1914, was that the slump in prices during the early months of the war had so discouraged the planters all over the world that they had seriously reduced their acreage. The inevitable result was that as soon as demand began to recover, which it did to an altogether unforeseen extent, prices began to rise; and there was nothing to stop them, except a possible restriction of demand owing to high prices. But such a reduction of consumption seemed certain; and on the other side it seemed safe to assume that if low prices had caused the reduction of area, high prices would bring a record acreage again. When, therefore, it became evident that the war was certainly not coming to an end this season, it was thought that the difficulty was merely that of putting things through for the

* Reprinted from the *African World*, dated July 7, 1917, and August 4, 1917.

remainder of the season, and that next year a big crop would bring everything back to normal again.

The Crisis Comes.

But "the best laid schemes of mice and men gang aft agley." Two things happened, both traceable to one source, to upset all the trade's calculations. America came into the war, and the first result was an extremely serious slump in prices in the Cotton Belt during February, which did much to shake the confidence of the growers in the permanence of the high price of cotton. In the second place, America's participation in the war led to a strong patriotic movement in favour of the increased growth of cereals in America, with the promise of very high prices, which naturally caused some uneasiness as to the possible effect on the acreage under cotton. These fears are now materializing in acreage estimates for the coming season of as much as five per cent. *below* last year's figure. Finally, the unrestricted submarine warfare began to have a noticeable effect on the quantity of raw cotton which could be shipped to England, not only in actual losses of shipping, but in high freights and insurance premiums. Then came the crowning blow. For the last two years the yield per acre has been below the average; and it was a fair risk to assume that this year the luck would turn and we would have a better season than normal from the point of view of weather. But the season, far from fulfilling this hope, began exceedingly badly. The pre-sowing conditions were very bad, in different ways in different parts of the Belt, and the first Government condition report was the worst for many years. To make matters worse it became increasingly clear that the situation with regard to the use of fertilizers was not improving; that the boll weevil was steadily eating its way into the Atlantic States; and finally that really serious inroads were being made into the labour supply of the cotton districts for the assistance of the northern industrial districts.

On the other hand, from the side of demand the signs were becoming very disquieting. The consumption was not diminishing at all in proportion to the reduced supply or the rise of prices.

England's consumption was of necessity being reduced by the difficulty of getting enough of the raw material, the difficulty of spinning it through lack of labour, and the further difficulty of getting the goods away to our foreign markets owing to the restrictions on shipping. American, Indian, and Japanese consumption, on the other hand, was going steadily up, as far as figures could be obtained; stocks everywhere were becoming seriously depleted, and there was simply no sign of a real check on demand which would have eased the pressure on supply. The reason at last became evident. The world must have textile fabrics of some kind, and though cotton was dear compared with what it had been, other things were still dearer. Cotton was still the cheapest thing obtainable. There was no substitute available, and many of our best customers in the tropics, far from being hard hit by the high prices of cotton goods, were really gaining more than they lost, because the prices of the raw materials they produce were rising still faster. The world's consumption of cotton was, therefore, not decreasing, while the prospects of supply were again most disappointing.

An Abnormal Rise.

The result of all these cumulative factors in the situation was a foregone conclusion, and the development of a serious crisis only a matter of time. It came slowly, but at last the trade as a whole began to realize that the shortage was not, as they had hoped, a thing of the past, that the real pinch was still to come, and that when it did come it would not go again in a hurry. The visible stock in Liverpool began to dwindle rapidly and the imports were less than normal consumption. Suddenly the market awoke to the fact that there was not going to be enough cotton left in the country to go round for the remainder of the season, and the inevitable scramble began for what there was. Prices, of course, shot up beyond all control; and on Wednesday, June 20, the futures market on the Liverpool Cotton Exchange was closed, practically under a Government order, with the spot price of American Middling at 19·39, from which it has since risen to 19·45*d*., a price which has not been equalled since 1865.

OFFICIAL CONTROL.

The Government has now appointed a Board of Control to carry the trade through the immediate crisis, and it is, unfortunately, obvious that that does not merely mean carrying it through to the end of the present season. The world knows now that, barring miracles, we are going to have another short crop this season, and whether the war comes to an end during the season or not, the scarcity is going to be very serious.

But the appointment of a Board of Control does not go to the root of the matter ; it will not add one boll of cotton to the world's supply. Surely it must be realized *now* that the conditions which have rendered such a state of affairs possible can no longer be tolerated. For the crux of the whole situation is that the world is still substantially dependent on the fortunes and the vagaries of the American crop for its cotton supply. That is bad for three reasons—(1) because the American growers, owing to the enormous increase in their cost of production, no longer find it pays them to grow cotton, except at what would formerly have been thought very high prices, say, twelve cents per pound as a minimum, and it is probably higher since the author made that calculation in Texas in 1913 ; (2) because the American crop cannot maintain its former rate of expansion except at still higher prices, owing to the increasing possibility and profit of crop diversification in what is no longer going to be exclusively the Cotton Belt ; (3) because our dependence on America alone puts the whole world at the mercy of the idiosyncrasies of the American planter, the chances of the market price in America round about the sowing season, and the vagaries of the American climate.

We must, therefore, at last, tackle seriously the question of securing a new and greatly increased supply from some other part of the world, and there is no doubt at all that it can be done. Fortunately, too, the British Empire, which, on account of the Lancashire industry, has so large a stake in the question, has also within its own boundaries the means of solving the problem. As will be seen from Table I, the British Empire already grows a large share of the best and the worst of the many varieties which

TABLE I.

The World's Cotton Supply, and the British Empire's Share in it.

Grade	Quality and staple	Where grown	World's crops	Empire's share	Per cent.
			Bales		
I	Best Sea Island...	Islands, South Carolina	10,000		
	(Longest staple)	West Indies	5,000		
			15,000	5,000	33
II	Second Grade Sea Island	Florida and Georgia	70,000		
		West Indies	2,000		
	Best Egyptian (Sakel, etc.) (Long staple)	Egypt	430,000		
			502,000	432,000	86
III	Egyptian	Egypt	1,000,000		
		Sudan	25,000		
	Staple American	Mississippi Delta, etc.	200,000		
	(Good staple)	Nyasaland, Uganda, and East and South Africa	50,000		
		Peruvian	125,000		
			1,400,000	1,075,000	77
IV	American	U.S.A.	15,000,000		
	(Ordinary staple)	Mexico	150,000		
		Brazil	300,000		
		Russia	1,000,000		
		West Africa	15,000		
		Levant	100,000		
		India	250,000		
		China and Corea	250,000		
			17,065,000	265,000	1·5
V	Indian	India	5,000,000		
	(Short staple)	Russia	400,000		
		China.....	1,800,000		
			7,200,000	5,000,000	66
			26,182,000	6,777,000	26

make up the world's total cotton crops. In the great middle grade, the "bread and butter" cottons which constitute two-thirds of the total, America is practically supreme and the British Empire is very badly placed. But that can be altered. There are many areas in the Empire which, if proper steps be taken, can be turned into huge cotton producers, and that at a price which will not only pay the growers extremely well, but will enable the world to get its raw material at something more like a reasonable price than the present. For the fact must be kept constantly in view that cotton is a cheap-labour crop, and the present trouble is due to the fact that labour is no longer cheap in America. Any country which has still reasonably cheap labour—and the wages normally

paid in India or Africa could be doubled more than once without coming up to the prohibitive level which has been reached in America—has an enormous handicap in its favour in cotton-growing against America. If the British Empire were properly developed it could produce all the cotton Lancashire wants, and let America keep most of her own crop, which is what she seems to be going to do.

The writer has recently in other places dealt with the possibilities of India as the most likely source of an immediate supply of cotton. In this series of articles he proposes to deal in the same way with the possibilities of Africa, for in his view the future of the world's cotton supply lies between these two continents and America. Under present conditions America has about reached her limits for the production of a cotton crop for export purposes; though it must be remembered that these conditions could be changed. The world requires more cotton, and it is open to any other country to step in and challenge America's supremacy. India, as an old-established cotton country with an enormous area already under cotton, and the inherited knowledge of centuries in its growth, has a great handicap in her favour, which, however, she seems none too willing to exploit. Africa (leaving Egypt for the moment out of the reckoning) is a good many years behind in the race, for it will take five or ten years, even under the most favourable conditions, to bring her up to the level of producing a million bales. But that she could do so, and much more, given time and money, is unquestionable; and if India will not seize the golden opportunity which now lies at her feet, it may be that Africa will be ready to take it up before India realizes what she has lost.

II.

THE POSITION IN EGYPT.

THE Egyptian cotton crop is comparatively small, but of very great value. As will be seen from the table in the first article of this series, it represents only about 6 per cent. of the world's total crops—say, $1\frac{1}{2}$ million bales (of 500 lb.) out of a total of over 25 millions—but it supplies 85 per cent. of the second and 73 per cent. of the third of the five grades into which the world's crops

may be divided. The value of Egyptian cotton is, on the whole, from 50 to 100 per cent. above that of American Middling, and the yield per acre is probably the highest in the world—say (until recently), 450 lb. of lint cotton per acre, against about 180 in America and about 80 in India ; while under the most favourable conditions actual yields of over 1,000 lb. of lint per acre have been proved in Egypt. Until recently, therefore, Egypt thoroughly merited the high title of the best cotton-growing country in the world.

It is all the more regrettable that during the last few years Egypt should have fallen so far below her former high records. A very marked deterioration has been going on both in quantity and quality, and the position is becoming so serious that it is high time something was done to call attention to the facts and to secure some remedy.

The deterioration is not a new thing. For years before the war, as will be seen from Table II, though the total crop was increasing steadily on the whole, the increase was only being secured by an extension of the acreage owing to increased irrigation facilities. The fall in the yield per acre culminated in the disastrous failure of the 1909 crop, which, however, did good in bringing to light the main cause of the deterioration—namely, an over-supply of water

TABLE II.

Year	Area	Crop	Average yield	SEASON'S AVERAGE PRICE (LIVERPOOL)	
				F. G. F. Brown	Premium over American Middling
	000 feddans	000 kantars	Kantars per feddan	Pence per lb.	Per cent
1897	*1,128*	6,544	**5·80**	*4·44*	*25*
190[illegible]	1,276	5,839	4·58	8·44	55
1907	1,603	7,235	4·51	8 81	43
1908	1,640	6,751	4·12	8·44	53
1909	1,597	5,001	*3·13*	**13·12**	**67**
1910	1,643	7,574	4·57	10·75	35
1911	1,711	7,424	4·33	9·56	57
1912	1,722	7,533	4·37	9·82	46
1913	1,723	**7,684***	4·46	9·44	34
1914	**1,755***	6,490	3·69	7·34	40
1915	1,186	*4,806*	4·05	10·42	39
1916	1,656	5,200*	3·14	?	?

The maxima are printed in bold type and the minima in italics. A *feddan* is approximately an acre and a *kantar* 100 lb. * Estimated.

due to insufficient regulation of the irrigation supply. It took some years of extremely bitter controversy to convince the Government of the truth of this theory, which was first put forward prominently by Mr. W. Lawrence Balls, D.Sc., in 1909; but it was done, and for a few years after 1909 things were better, thanks partly to the seasons and partly to the better understanding of the needs of the crop as regards water-supply. By 1913 the corner had apparently again been turned, and there was once more every prospect of a large increase of the crop. Huge drainage works had been undertaken by the Government to remedy the permanent results of the over-watering in certain districts, and the raising of the Assuan Dam had made it possible to undertake great reclamation works in the Northern Delta, which ought by this time to have added another million acres to the available cotton area. At the same time further irrigation schemes were on foot in the Sudan, which were to provide for still further extension of the area both in the Sudan and in Egypt.

The improvement of the quality of the crop was also making satisfactory progress. The scientific staff of the Khedivial Agricultural Society, subsequently transferred to the Government Department of Agriculture, was doing excellent work, and the prospect of real improvement in the varieties chiefly grown was practically a certainty.

Upon this promising state of affairs the war descended like a blight. Before then the Government had made the great mistake of allowing Dr. Balls, who was responsible for the scientific work on cotton-breeding, to leave the country on the expiry of his first contract with the Agricultural Department. When the war broke out the Government adopted a policy of restriction of area, which in the light of subsequent events can only be described as panicky. Before that policy could come into force its folly had been realized, but the mischief was done, though how far the subsequent restriction was due to the Government action and how far to natural economic causes it is hard to say. The fact is, however, that Egypt showed probably the highest restriction of acreage of any country, and the crop in 1915 was the lowest on record in modern times... (Table. II.)

But the reduction of the crop was not entirely due to restriction of acreage. In 1914 a new cotton pest, the pink boll worm, or seed worm, began to show in earnest what it could do to reduce the average yield per acre. In this, again, the Government were not free from blame. They had been publicly warned in 1913, when the pest first threatened to become serious, of what would be the result if immediate steps were not taken to check its advance in the early stages, and for one reason or another they did practically nothing. The result was that the pest got a firm hold, and now its effects can be seen in the fact that while the acreage has increased again (though not to anything like pre-war figures) the average yield per acre has apparently sunk permanently by about 30 per cent., and the crop is reduced to about two-thirds of what it was before the war. That means a net loss of anything over ten million sterling per annum.

At the same time, the deterioration of the crop in quality, which had at least been checked before 1913, has begun again at probably a greater rate than ever. A few years ago the staple variety throughout the Delta was the ordinary Brown Egyptian or Afifi cotton, while Jannovitch and Abbassi provided the bulk of the higher grades, and Upper Egypt was almost entirely devoted to Ashmouni, or Upper Egyptian as it is called in Lancashire. About 1909 a most promising new variety, known as Sakel for short, was introduced by one Sakellarides, which very quickly came to the front and outclassed all the previous best grades. It had one further advantage, that, whereas Jannovitch would only grow well in certain districts, Sakel seemed to flourish everywhere in the Delta. The result was that Afifi, which had been deteriorating seriously, was rapidly displaced by the new variety; but unfortunately, as always happens with new cottons, the desire to accelerate its introduction on a large scale proved its undoing. The seed became hopelessly mixed and the staple deteriorated very rapidly, and now it is extremely difficult to find any cotton in Egypt of the old superior grades. And not a single new cotton has been introduced, so far as is known in this country at any rate, to take the top place. When Dr. Balls left Egypt he had several just ready for

propagation on a commercial scale. What has become of these cottons since ? Had he remained in Egypt they would by this time have been ready to take the place of these other played-out varieties, and that, too, under a new system of regulation of seed supply which would have gone far to prevent, or at least would have very greatly retarded, the apparently inevitable process of deterioration which has hitherto overtaken every new cotton under ordinary commercial handling.

While things have thus been going from bad to worse, all the new schemes which were under consideration for the future extension of the area under cultivation were summarily suppressed owing to the alleged lack of money due to the war. That was, perhaps, inevitable at the time, but it is no longer possible to accept the excuse in view of the financial position of Egypt to-day, and at last it is proposed to resume the execution of these works. It is absolutely essential that this should be done at once. If the finding of the money and the pushing on of the works are to be postponed till "after the war," they might just about as well be postponed to the Greek Kalends.

The effect of all this on the price of Egyptian cotton hardly needs to be described. After a long spell, during which the premium of Egyptian over American was distinctly below normal, Egyptian in November last suddenly began to shoot up till in April it touched the highest premium on record, namely, 110 per cent. To-day Egyptian prices are simply chaos.

This debacle of the Egyptian crop is all the more serious because the rival supplies of fine cotton are so seriously threatened in another direction. The chief rivals of the best Egyptian varieties are the Florida and Georgia Sea Island cottons, grown in the districts of these States and South Carolina near the sea, from original Sea Island seed. But the dreaded boll weevil in its apparently irresistible progress is now fairly into the Atlantic States, and there seems absolutely no reason to hope that its advance will be stayed here any more than it was in the Mississippi Valley, where the conditions are similarly favourable to its advance, with mild winters and ample vegetation for winter harbouring. It is very probable,

therefore, that some of these days we shall wake up to find the whole of these districts abandoning Sea Island, which is a difficult crop to handle, and highly speculative in its yield and price, and turning over to short-stapled, quicker maturing varieties, of which at least a partial crop can always be secured in spite of the boll weevil. What, then, will be the position of the world's fine spinners, and what will be the feelings of Egypt when such an opportunity is offered them of capturing the world's markets for fine cotton, and they are unable to take it?

There is only one gleam of hope in the situation. On the new Cotton Committee, which has at last been appointed by the Board of Trade, there are at least three men who know Egypt and Egyptian cotton better than, perhaps, any others in the world. Mr. J. W. McConnell is a member of the largest fine spinning concern in the world. Sir Ronald Graham was in Egypt through the whole of the cotton controversy, and is thoroughly familiar with its cotton-growing conditions. Finally, Dr. Lawrence Balls himself is on the Committee. Only one other thing is needed—that the fine spinning section of the trade should realize its danger and use all its influence to see that these gentlemen are given a free hand and a very clear mandate to take up this question of the supply of fine cotton without a moment's delay, and with the one object of having matters remedied, even if it should involve "wigs on the green."

CO-OPERATIVE SOCIETIES FOR THE SALE OF COTTON IN THE SOUTHERN MARATHA COUNTRY.*

BY

THE HON. MR. G. F. KEATINGE, C.I.E., I.C.S.,

Director of Agriculture and Co-operative Societies, Bombay

It is only when the separate sale of produce by many individuals presents some special difficulty to the producers or puts them at some obvious disadvantage with the buyers that co-operative sale is likely to be successful. When no obvious difficulty is involved, each producer may well think that in acting as his own salesman he will be able to look after his own interests most effectively. In many cases, however, great advantages can be secured by the co-operative sale of produce, and have been secured to the producer by this means in many countries. In such cases the benefits aimed at are usually some of the following :—

(*a*) Saving the time of the producer ;

(*b*) facilitating the transport of produce to the market ;

(*c*) securing fair dealings for men who have little business knowledge ;

(*d*) securing for the co-operative society, and so for the producer, the profits of the middleman ;

(*e*) securing better prices by grading and standardizing the produce ;

(*f*) securing a different class of purchasers by selling in bulk on a large scale ;

(*g*) securing a good name for honest dealings and high class produce.

* Reprinted from the *Bombay Co-operative Quarterly*, vol. I, no. 1.

Many of the advantages enumerated above are dependent on one another; but it will seldom be possible to secure them all. When the conditions of any business are such that all or a large part of these advantages can be secured to the producers, then there is a good *primâ facie* case for the establishment of a co-operative sale society.

Before considering how far the conditions of cotton sale are adapted to such treatment as is indicated above, a general warning must be registered. The saving of time and the facilitating of transport are mentioned as two desirable objects to achieve; but it must be remembered that in India the maxim that "time is money" is not of general application. There is an enormous amount of labour running to waste which seeks no employment or only light and partial employment, and any organization which tends to reduce existing labour may merely result in giving additional leisure to men who were before only half employed. It is, presumably, always desirable to save unnecessary labour; but, under the conditions referred to, it will not pay to incur expenditure on so doing; and this applies with particular force to the tract of country which is considered in this article. The same argument applies in a less degree to the transport of cotton to the market. Most cultivators have a cart and bullocks, and if these were not utilized in carting the cotton, they would most probably stand idle. The cheapest agency for getting the cotton to the market is usually the grower with his cart and bullocks, and it would seldom be profitable or desirable for any co-operative society to attempt to relieve him of this work. Items (*a*) and (*b*) enumerated above, therefore, drop out; and in order to consider how far conditions favour such co-operative action as indicated in (*c*) to (*g*), a short account will be given of the existing system of marketing seed-cotton in the Southern Maratha Country, the tract with reference to which this article is written.

There are four methods by which cultivators sell their cotton:—

(1) Some of the poorest sell their cotton standing in the field before it is ripe.

(2) Some who have not much cotton to sell and who have no facilities to take it to the market, sell the gathered

cotton loose in the village to some small dealer, who, in turn, markets it as shown in (4) below.

(3) Some of the largest cultivators take their cotton to the market and deal direct with the buyers, sometimes getting it ginned before they sell it.

(4) The great majority of the cultivators make their loose seed-cotton up into *dokras* (bundles in sacking) and take it to the nearest market, where they sell it through their *dalal* or agent.

What classes (1) and (2) most need is a little financing, and the ordinary village co-operative credit society can do this. Class (3) comprises the men of means and intelligence who are not greatly in need of assistance. Class (4) comprises the people who stand to gain most if effective co-operative sale can be substituted for their own haphazard methods of marketing. The present system is as follows :—

Each cultivator takes into the market a certain number of *dokras* of seed-cotton roughly done up in sacking and weighing about three or four hundred pounds apiece. When he arrives at the market he goes to a *dalal* and puts himself in his hands. If there is any buyer in the market ready to buy from the *dalal*, the cotton is weighed in the presence of the cultivator and sold on the spot. This. however. seldom happens. What usually occurs is that the *dalal* notes down the number of *dokras* received from each man and marks them with his name. The *dokras* of each cultivator are not kept separate, but are all mixed together, though sometimes a careful *dalal* will keep separately *dokras* from a village noted for high ginning percentage, and will obtain a slightly better price for them. The actual sale of the cotton does not necessarily take place on the day on which the cotton is brought to the market ; indeed, in many of the smaller markets, sales take place only once in two or three days when the buyers come to purchase. When the *dalal* has got together a number of small lots of cotton and a buyer is found, the *dalal* will sell all the cotton that he has on hand. The buyers consist either of regular dealers in seed-cotton or the agents for mills or export firms. Thus in the great majority of cases the cultivator does no

more than bring his seed-cotton to the market and hand it over to the *dalal*. The weighment is not made in his presence, nor is the price fixed in his presence. He puts himself entirely into the hands of the *dalal*, and the cotton which he may bring in on any particular day is sold, not as a separate lot, but together with small lots belonging to other persons. Subsequently the *dalal* will make out his account, showing the weighments made and the prices arrived at, crediting the sale price and debiting his commission and other charges.

Now from the cultivator's point of view, these arrangements have many defects, which are usually stated as follows :—

The cultivator has to depend entirely on the honesty of the *dalal* and his servants for the accuracy of the weighments, the settlement of the price, and its payment to him in full ; and it is common for cultivators and others to assert that frauds are often committed at the expense of the cultivator, and that, in extreme cases, the cultivator is credited with only a quarter of the cotton that he actually brings to market. It is by no means contended that all *dalals* are dishonest : but the fact remains that the system allows ample opportunity for fraud.

The *dalal* admittedly makes the following charges for selling a *naga* (1,344 lb.) of seed-cotton :—

	Rs.	A.	P.	
From the buyer	1	4	0	*dalali*
From the cultivator	0	12	0	
From the cultivator	0	6	0	***hamali* (handling charges)**
From the cultivator	0	1	6	**for charity**

And sometimes there is a small additional charge made to the cultivator in the interests of some object of public utility. Thus, both the buyer and the seller pay R. 1-4, but, since the price of the seed-cotton is settled with reference to the current price of clean cotton in Bombay, it is on the cultivator that the full charge of Rs. 2-8 per *naga* really falls.

In addition to this, a deduction of 14 lb. per *dokra* is made as an allowance for the weight of the sacking, though this latter usually weighs only 7 to 10 lb., and if rain falls a deduction up to 30 lb. is made on this account. A further deduction of 2 lb. per *dokra* is

made for sample purposes, and in some cases a charge for insurance. The net result is that the cultivator has to pay as ordinary market charges about Rs. 6-8 for each *naga* of cotton. It may be argued that a deduction for the weight of the sacking is necessary. This is true up to a certain point; but the cultivator has to pay for the sacking and gets no allowance for its value made to him on the sale of his cotton.

Now these charges may or may not be fair. That is not the point at present under consideration. Many cultivators think that they are not fairly treated. Why then do they put themselves so completely into the hands of a *dalal?* The answer is that they have no alternative, and for the following reasons:—

(*a*) Most of the cultivators are ignorant of business methods, many are incapable of checking weighments, and few are capable of calculating prices.

(*b*) The individual cultivators bring in small lots of cotton to the market, while the buyers want to buy big lots. A middleman is therefore necessary to put the two in touch with each other.

(*c*) The *dalal* advances money to cultivators against their crop, making it a condition that the latter will market their cotton through him.

(*d*) The *dalal* advances sacking to the cultivators on the same condition.

It is clear, therefore, that, in the absence of any other agency to perform the work now done by the *dalals*, the latter are essential to cultivators. There is no doubt that an efficiently managed cotton sale society could undertake all these duties, and a consideration of the existing methods of sale, as detailed above, certainly points to the conclusion that such a society could do a great deal to guarantee fair treatment to the cultivator, and to secure to him a share of what now constitutes the legitimate profits of the *dalal.* These are objects (*c*) and (*d*) mentioned at the beginning of the article.

As regards the remaining objects, namely, grading, securing a different class of purchasers, and establishing a good name, it will

be convenient to consider them together since they are connected with the organization of the cotton trade as a whole. So far we have considered the operations between the growers, the *dalals*, and the buyers of seed-cotton, and have had an opportunity of estimating how far they are susceptible to co-operative treatment. We must now consider the ultimate fate of the cotton, after it has been ginned and baled, in order that we may estimate the further advantages which may be obtained for the producer if the society can put cotton on the market in the condition in which the users require it, and if it can secure the confidence of the large buyers. All cotton is, of course, destined for the mills, but it will be convenient to divide the buyers into Indian millowners and dealers who buy cotton in order to place their purchases on the market in Bombay or abroad. The former require the cotton in such a state that it will give the best results in their mills, the latter in such a state that it will yield them the best profits. No doubt the real interests of the two classes are identical, but the difference is that the mill-owners get their profits only from the finished cotton product, while the dealers get their profit on each deal from the difference between the price at which they buy and the price at which they sell. If the former get cotton which is inferior to what it purports to be, it is they who will lose, while the latter can usually pass it on at its face value. Consequently it is found that some large millowners make careful arrangements to secure good quality cotton direct from the growers, and to obviate the chances of adulteration in the local markets. It is they who are most susceptible to consideration of quality, and it is to their requirements that a cotton sale society which aims at grading should endeavour to conform. The main considerations in grading cotton are ginning percentage, staple, and class.

Ginning percentage. The ginning percentage (*i.e.*, the percenage of the weight of lint to the total weight of the seed-cotton) varies greatly with different varieties of cotton, and even with the same variety it varies considerably according to the season, the natural conditions of any locality, and the individual strain of cotton. Thus in the case of Kumpta cotton, which forms the bulk of the

cotton grown in the Southern Maratha Country, the ordinary ginning percentage may be taken at 25, but it will be found that in some localities it will be 2 per cent. better than that of the adjacent tracts. This means that on any given quantity of seed-cotton from this locality the ginner will get 8 per cent. more lint than from that of the surrounding tracts, and consequently the seed-cotton from this tract is worth 8 per cent. more, which at ordinary prices means about Rs. 12 per *naga*. Buyers of seed-cotton do make some rough attempt to estimate this difference in ginning percentage by the feel of the seed-cotton, but such methods are very inaccurate. Samples of seed-cotton with ascertained ginning percentages of 22, 25, and 28, were submitted to a number of buyers in Hubli. The samples with percentages of 22 and 25 were lumped together, and, as regards ginning percentage, were valued by them at the ordinary market rate. The sample with a ginning percentage of 28 was admitted to be better, and on this account was valued at Rs. 2 per *naga* above the ordinary market rate. In point of fact the difference in value between sample (1) and sample (3) was Rs. 31 per *naga*, and the difference between sample (2) and sample (3) was Rs. 16 per *naga*. This shows the advantage that may be gained in this respect by careful grading, and the matter is important because pure strains of Kumpta cotton have been isolated which gin 2 per cent. and more above the average, and the seed will shortly be available on a large scale.

Staple. In the matter of staple the millowner looks to length, strength, and uniformity. It is not proposed to consider here the possibilities of improvement in the length and strength of staple, but even under existing circumstances the question of uniformity is important, because in some tracts Kumpta cotton and American cotton are grown mixed in the field, come on the market mixed, and get further mixed in the market. The length and strength of the staples in these two varieties are different, and if mixed lots are lumped together with unmixed lots the value of the whole is depreciated. In such tracts by careful grading a better price can be obtained for unmixed lots, and in this way the practice of mixing either in the field or in the market will be discouraged. Further, the value of the

uniformity of staple secured by using seed of pure strain can be realized if the produce of such seed is kept separate and made available in large lots.

Class. Class depends on the cleanliness of the cotton and the condition in which it is placed on the market. The condition in which Kumpta cotton is placed on the market is very bad. This is due partly to the fact that the leaf is very brittle and has a tendency to get mixed up with the cotton, and partly to the very careless methods of picking. If the cotton is picked in the early morning the leaf is less brittle, and clean picking is easy ; but as a rule cotton-picking begins at about 10 o'clock when the leaf has become brittle, and no attempt is made to pick cleanly. The brittle leaf is crushed into the cotton, and the bases of the bolls are pulled off with the cotton. The heaps of picked cotton are laid on the leafy ground in the field, where fresh leaf and earth adhere, and the wind adds additional leaf and dust in the course of the day. When little or no allowance is made in the market price for clean picking, it is natural that no one should worry about it, for the leaf and dirt all add to the weight and are paid for as cotton. But such methods, of course, depreciate the value of the cotton. It is almost impossible to remove completely the small particles of leaf that get mixed up with the lint, and the elaborate process of cleaning involves expense and a further loss of lint. It is the cultivator who ultimately pays for such expenditure and losses. The losses involved in cleaning a dirty sample, in excess of the losses involved in cleaning a carefully picked sample, work out something as follows per *naga* of cotton :—

	Value		
	Rs.	A.	P.
Loss through opener, 14 lb. (seed-cotton) ...	1	8	0
Cleaning by hand after ginning, 2 lb. (lint) ...	0	12	0
Loss in willow-machine, 10 per cent. (lint) ...	15	0	0
TOTAL ..	17	4	0

A *naga* of clean-picked cotton is probably worth Rs. 25 more than a *naga* of cotton picked dirty, and the difference in the cost of picking is about Rs. 5. It is of course a question to be decided for any variety of cotton whether the extra cost of picking clean is

greater or less than the cost of subsequent mechanical cleaning; but if the cultivator thinks that he is really getting paid for the leaf and dust that is added to the cotton he is mistaken; and if a sale society were to grade carefully cotton for cleanliness he could be made to realize that this dirty picking, which virtually amounts to the intentional addition of leaf and dirt, really causes him loss and not gain.

The fraudulent practices that take place in the course of the handling of the cotton, adulteration, admixture of short-staple cotton and cotton waste, damping, etc., are a matter of complaint and comment on the part of the millowners and of impartial observers. The tract under consideration grows from one to one and-a-half million acres of cotton, and the cotton grown, Kumpta and Dharwar American, to-day (May 28th, 1917), head the list of values quoted in the Bombay cotton market, standing at Rs. 425 and Rs. 410 per *candy*, respectively. The millowners want the cotton clean, uniform, and unmixed, but complain that under existing arrangements they cannot get it. It can therefore hardly be doubted that there is a great opening for effective work by cotton sale societies, and that by careful work they can make evident the truth of the maxim that honesty is the best policy.

A century and more ago, when England was still a country of farmers, it was common to find in rural parts inns known as "The Four Alls" having a sign board bearing the legend, "The king governs all, the bishop prays for all, the soldier fights for all, and the farmer pays for all." This statement still applies to India. The farmer may be content to pay for what he receives; but it is hard on him that he should have to pay for the inefficiency of a trade organization which he does not control.

If a sale society can establish a reputation for honest dealing and for high class produce, it may be hoped that the benefit which it will confer on the community will be more than what is represented by the hard cash which it secures for its members. In the cotton districts the cotton trade is the trade *par excellence*, and dominates all other in the estimation of the people; and when it is found or commonly believed that it is permeated by chicanery and sharp

practice, the effect must be to blunt the moral sense of the community. On the other hand, societies which stand for honest dealing might well become the rallying ground for persons with higher aspirations, and in the course of time might do much to raise the moral tone of the local trade and of the community generally.

To consider in brief some questions of practical organization, it cannot be repeated too often that co-operation is not a substitute for efficiency. The management of the sale society must be efficient, and the commission charged to the cultivators must be sufficient to pay for this. The work will naturally be divided between the villages and the market. For making advances against the crop and for supplying the sacking, the agency of the village credit society will come in, and it is through the influence of the village societies that pressure can be brought to bear on members to bring in their cotton clean and unmixed. The marketing operations must naturally be done at the market, but the village societies and the cotton-growers must control the society and feel that it is their own; otherwise mutual credit cannot be established. Such are a few of the general principles that it seems desirable to formulate. The practical details must in each case be worked out with reference to local conditions. A start has been made this year by the establishment of four cotton sale societies in the Dharwar District, which has always taken the lead in co-operative enterprise. The start, though small, has been encouraging. Much strenuous work will be required to reach the ideals which these societies have set before them, but the idea of co-operative cotton sale has already attracted the imagination of the cultivators, and it is to be hoped that these societies will secure the sympathy and goodwill of the Cotton Trade.

SOME RECOLLECTIONS AND REFLECTIONS.*

BY

H. R. CROSTHWAITE,

Registrar of Co-operative Societies, Central Provinces.

So much has been written about Co-operation that it is very difficult to find anything fresh to write about. I have told the editor so; but he wants me to send him an article, and so in one of the most secluded spots in Tihri Garhwal with the snow-covered mountains in full view, I send my thoughts back over the twenty odd years during which I have been connected with co-operative work and jot down a few lines which may be of interest.

Co-operation in Britain and co-operation in India are two very different things. In the process of turning herself from an agricultural into a manufacturing country, England created for herself special economic conditions, and workers flocked from the fields to the factories. I have seen, in the north of England, excellent co-operative stores owned by working people whose grandfathers lived on the land and did not herd together in cities. The biggest shirt factory in the world, in Yorkshire, is worked not only on co-operative but co-partnership lines. Close to the English industrial centres, I have passed over bleak uplands of poor soil which still bear the marks of the plough. They were last sown with wheat when Napoleon was the terror of Europe and was planning the conquest of the world. Then came Napoleon's downfall, Trafalgar, Waterloo, the repeal of the Corn Laws, and Free Trade. England's food supply was no longer threatened. She was, as she still is, the greatest carrying country in the world, and agriculture declined

* Reprinted from the *Bombay Co-operative Quarterly*, vol. I, no. 1.

as the prosperity of the manufacturing industries increased. Education made vast and rapid strides, and inspired by Robert Owen, the town-dwellers and factory-hands moved, naturally and not under Government leadership, towards mutual co-operation. Twenty years ago it might be said with accuracy that co-operation in agriculture and amongst the agricultural classes scarcely existed in England. Large farms were the rule and the field labourer was extraordinarily ignorant, miserably paid, and very badly housed. Only a few years ago, I went round the cottages of a village, not forty miles from London, in the company of a friend who was standing for Parliament. "Home Rule" and "Tariff Reform" were matters which were supposed to be agitating the minds of the voters. "Well, Mr. Brown," said my friend to a stalwart farmer whom we met in the street, "Tariff Reform suits you, I suppose." "I don't know so much about that," said Mr. Brown, "what is the Parson for?" "Ah," replied my friend, "he is for Free Trade." "Then I plump for Tariff Reform," was the farmer's decision. "Parson has raised the rent of that glebe land of his which I have held for twenty years and my father before me, and I won't vote same as Parson." Another free and independent voter informed us that he was "All for Home Rule." Asked for his reasons he said, "Because then we shall have a 'free breakfast table.'" And it transpired that he understood this particular electioneering phrase to mean that the State would supply him with breakfast for nothing. It struck me that a great deal of preliminary educative and propagandist work would be wanted in rural England before there could be a really popular move towards co-operation in agriculture. In the matter of industrial co-operation, on the other hand, England has always been *facile princeps*. For one thing, education is more advanced and more easily to be had in industrial centres; for another, the town-dweller has his wits sharpened by the atmosphere of busy competition in which he is brought up; and against the strain and stress of that competition he uses co-operation as a protection. But even before the present war there had arisen in England champions of rural reform, men who saw the danger of an excessive industrial development at the expense of the independence of the

nation's supply of food and raw materials. These men, at their own expense, founded the English Agricultural Organization Society, and it is to that society that the credit is due for such progress in rural co-operation as existed in England before the war. Nowadays, as we all know, the British Government is devoting the most strenuous efforts to the establishment of agriculture on a modern and scientific basis. The pendulum had swung too far towards a one-sided industrial development; the scales have fallen from the nation's eyes, and, in future, rural progress will be a matter which no party will be able to neglect. Organization, money, leadership—all these will be necessary, for there is not a country in the world in which the cultivator can fend for himself if left entirely to his own devices. What we want in India is less dependence on Government for leadership in matters pertaining to the moral and material development of the country. Take Ireland, Denmark, Germany, Italy, Japan, and examine the history of their co-operative development. True, Government has, in each country, played an important part in that history; but there is also a record of private enterprise and of public spirit which India cannot yet match. Recently, I spoke to a member of the Imperial Legislative Council, and, as he is a farmer, asked him whether he could not organize a society on the lines of the English or Danish or Irish organization societies. He said that he was afraid that there was no prospect of success. Not only would there be no subscriptions, but there would be no enthusiasm and much active oppo ition. I thought of my English friend Mr. Brown, and of the little weakling plant of rural co-operation as it existed in England before Germany challenged the British Empire. And I wonder how long it will be before India wakes up.

I remember going to see a so-called "demonstration farm" in the Central Provinces about twelve years ago. I had been told off to accompany the late Sir Edward Law, who was then Finance Member. The farm was a miserable affair, just a single field of *juar* (*Andropogon Sorghum*). However, Sir Edward Law went miles in a country-cart to see it; he had been informed, I suppose, that the Agricultural Departments would want more money, and like the great man he undoubtedly

was, went right down to the very root of the matter and saw for himself how inadequate the demonstration was—he knew the shoe pinched but had to find out how tightly it pinched. During the last ten years there has been a very remarkable development of the Indian Departments of Agriculture; but I believe that the point is near, if it has not already been reached, at which private enterprise must step in and supply, by means of organization societies, that main channel for the activities of the experts which is supplied in other countries by such societies. The difficulty which strikes me is the backward state of rural education—general education and enlightenment, I mean, not mere book-learning. And how is the cultivator to understand if he has not had matters brought home to him? I plead for a campaign of rural education in India. If this great country is to be a self-contained unit of the Empire, then there must be not only a reform but a revolution in her system of agricultural economy. For most modern industries the raw material supplied by the fields is essential: and in many parent industries this material must be produced within a short distance of the factory if profits and efficiency are to be secured. Intensive cultivation is, indeed, a corollary of the modern factory, and I need not labour the point that industries and agriculture, whether in the matter of labour or of markets or of material, are interdependent An examination of Japanese conditions will bring home the truth of this. But if you wish to get money out of a business you must first put money into it. A great deal of money is wanted for the improvement of Indian agriculture. The improvement of agriculture and the need of the cultivator for increased capital will progress together: and the ideal which some people appear to cherish of rural co-operative credit societies requiring no credit can only be reached by means of economic stagnation and the stoppage of human progress. In Germany the rural societies borrow because they progress from one stage of improvement to another on the strength of their credit, and their credit depends upon their ability to progress. And that ability in turn is the result of the research work done by the scientific experts paid by the State. But the scientific expert is not expected to devote his attention to the organization and supervision of

co-operative societies. The co-operative societies eagerly assimilate and apply the discoveries of the scientists, and the mainspring of their enterprise is the thoughtfulness and vigour of their members. It has always been so in Germany, and systematic rural education and propagandist work have brought about this happy result, coupled, as they have been, with a suitably designed financial machinery for the fostering of thrift and the dispensation of credit. The Post Office Savings Banks of Germany and of Japan, and of other countries as well (but not those of Great Britain), work in co-operation with and not as rivals of the co-operative banks. And in India, a country of small holdings in which the co-operative organization is following the lines which have met with success in other countries of small holdings, it is, I suggest, to be desired that there should be a similar co-operation. The result would probably be a more attractive rate of interest for the depositor in the Post Office Savings Bank and a more favourable rate of interest for the borrowing member of a co-operative society. As matters stand at present, there appears to be a gap in the finances of the country which could be bridged with great advantage to the State. I venture to prophesy that in Great Britain the changes which are gradually converting a country of big farms into one of small holdings will, before very long, bring about a partnership between the Post Office Savings and Co-operative Banks.

The credit for introducing the idea of modern co-operation into India has been assigned to various people. Some mention the names of Sir William Wedderburn, Sir Charles Bernard, Lord Curzon: others point to the Nidhis and state that Indian co-operation is autochthonous. The first co-operative societies in India were actually organized by my brother, the late Captain T. J. Crosthwaite, and by Mr. (now Sir Edward) Maclagan, in the Punjab. Mr. Dupernex, too, was an early and fervent apostle of the cause, and India owes him a great debt of gratitude. It was no easy thing to be an advocate of co-operation in India in the first few years of the present century. I remember organizing a few societies before the first Co-operative Credit Societies Act of 1904 was passed. The co-operative idea was very strange and very new. A Chief

Commissioner examined my infant societies and wrote a note which showed quite clearly that he was under the impression that Mr. H. W. Wolff and Raiffeisen were contemporaries! Mr. Dupernex told the International Co-operative Conference at Buda-Pesth (1904), that the general opinion was that co-operation in India would never succeed. I don't think anybody had a definite working plan of co-operative organization in those early days of the movement in India. Sir Edward Law's Committee dealt only with the basic unit of the co-operative structure and left the more difficult parts, namely, the central and provincial banks and the federations, severely alone. We have not as yet got an apex bank in every province : and the value of federation is not yet understood in India. There must be co-operation between the various districts within a province : and there must be co-operation between provinces. In the end, I hope we shall get our Imperial Co-operative Bank, not superimposed as in the case of the Prussian State Bank, but as a product of joint action taken by the provincial banks. Until we do get our Imperial Bank we shall have to put up with the many difficulties and inconveniences caused by the absence of elasticity in our finances. It is also time that we took measures to organize an All-India Co-operative Conference, to supplement but not necessarily to replace the Conference of Registrars. There are, it is true, a considerable number of non-official workers, but if the co-operative movement is to be effective this number must be greatly increased. There is not, from the non-official side, half enough bite and sting in the matter of co-operative effort. On the official side too, there should be a more intimate knowledge of co-operative science, for, indeed, modern co-operation is a science. Weeds are about the only things that can be grown without any trouble, and we must study the methods of other countries, accepting what is suitable for India and rejecting what is not. India has great need of more men for co-operative propagandist work.

Some people expect too much of co-operative institutions; others do not understand that co-operation means much more than the provision of cheap credit. The future of the co-operative movement in India is in the hands of India's young men. A short

time ago the Chairman of the Saving National Bank of New York was urging the needs for expansion at the meeting of the National Foreign Trade Convention at Pittsburg. "Naturally the bank of the future," he said, "should be a source of helpfulness, a court of business resort for the businessman. It must provide him with information, instruction, suggestion, direction, and whatever other assistance may be required, to supplement his own equipment, to guide him through difficulties, to keep him in effective touch with business and financial methods and activities throughout the world." Alter the wording a little and this declaration of aim will be found suitable for co-operative banks in India. Our banks exist for their customers and they cannot do too much to increase the moral and material welfare of their customers. Those who expect too much of co-operative institutions forget the limitations of environment and unequal development of the many countries of which India is composed. The progress of co-operation depends upon progress in many other directions. It depends on the development of education, of railways, of roads, of markets. It depends upon the supply of workers, paid and unpaid, and most of all, perhaps, on the degree of importance attached to economic development by those who are the elected representatives of their countrymen. *Ex nihilo nihil fit.* Bricks cannot be made without straw. And those who desire to see the co-operative movement go ahead in India should do all they can to secure the general development of the country and should attach to co-operation that same degree of commanding importance which is attached to it in other countries. Co-operation in India has not as yet come into its own. I have put down more reflections than recollections. A few "snapshots" must conclude what I fear is a rambling and badly constructed article. I remember a brief official endorsement on the proposals which I submitted for the first co-operative central bank in the Central Provinces. It was to the effect that there was no need and no scope for the bank. But that bank has prospered for ten years. I recollect seeing a Bania weeping bitterly because he had taken shares in another central bank (*Deputy Commissioner Sahib ke hukm se*) and he looked upon the money as lost for ever! That

same Bania is now a ready depositor; we gave him back his money and dried his tears, and I suppose he thought, after that, that co-operation was not such a bad thing after all. Between the early Co-operative Conferences and Congresses, with their long speeches and dreary readings of long essays, and the proceedings of the recent gatherings what a difference there is! The improvement is wonderful. Deeds count more than words now; in those early days words had to make up for the absence of deeds. Lastly, go down to the primary societies and examine the members. Instruction, training—drilling, if you like—repeatedly given have had effect. The cultivator *can* be taught what co-operation means though it is the work of years to teach him. And, best and brightest augury of all, he wants his society to continue and serve the interests of his sons and their sons after them. There need be no pessimism as regards the future of the co-operative movement in India; nor need we feel the apprehension exhibited by John Ruskin, when after listening patiently to G. F. Holyoake for an hour or more, he was moved to exclaim, "What I fear most is co-operation amongst scoundrels!"

AGRICULTURAL PROGRESS IN INDIA.*

BY

A. C. CHATTERJEE, I.C.S.

MUCH attention is now being devoted to the problem of industrial development in India. The forest, mineral, and agricultural resources of India are large, and only very partially utilized in the country itself. On the other hand, the population is immense, and but for temporary circumstances like plague and famine, has under an ordered Government a natural tendency to increase at a rapid rate. The avenues of employment are few, narrow, and overcrowded. Recent events have brought into prominence the urgent necessity of making the country self-contained with respect to all the essential requisites of life in peace and war. It is all to the good, therefore, that the State and the people should seriously address themselves to the development of the resources of the country. There is, however, some danger that in the popular mind of India a concentration on the purely industrial aspect of the economic problem may obscure the importance as well as the manifold requirements of a concurrent progress in agriculture. As has been recently pointed out, agriculture is the most directly productive of all industries. European countries, and Great Britain among them, are now realizing the fatal danger of neglecting agriculture for the sake of non-agricultural industries. There is every indication that even during the progress of the war, and most certainly after the war is over, all countries in the world will strain every nerve to improve their agricultural production in quantity as well as quality. Competent observers have, indeed, expressed their apprehension lest the States,

* Reprinted from the *Indiaman*, dated 12th July, 1917.

that have remained neutral in the present struggle and have consequently suffered less from its direct effects, should have an undue advantage in this matter over countries whom necessity, honour, or humanity have drawn into the vortex of the war. It will be a disaster for India if she falls behind in this agricultural competition. Two men out of every three in India are directly dependent on agriculture for their livelihood. The annual agricultural produce of India has been estimated to amount to a thousand million sterling in value. It is with the surplus of this produce that India at present procures many of the essential necessities of life and civilization. It is mainly out of the surplus of this produce that India can hope to accumulate sufficient capital, which is one of the prime requisites for any real and effective industrial development. Any falling off in the price or comparative value of her surplus agricultural produce will, therefore, prove not only an insuperable obstacle in the way of industrial progress, but will lower still further the already low standard of life in India, and thus fetter national development in every direction.

Fortunately, the Government of India are now fully alive to the supreme importance of the agricultural problem, and signs are not wanting that large sections of the population are also responding to the stimulus for agricultural progress that is being imparted, consciously and unconsciously, from various quarters. It is, of course, well known that the State of India is directly and intimately interested in the welfare of agriculture. A very considerable portion of its revenue is derived from the profits of agriculture. Appreciation of this cardinal fact has been present in the minds of Indian rulers in all ages, but a sense of the corresponding obligations and responsibilities is by no means ancient. It was not realized that beyond the maintenance of law and order the State had any special duties towards the development of agriculture. The explanation of this indifference is to be found in the fact that until about the middle of the nineteenth century the area of land available for agriculture was in excess of the number of men seeking a livelihood from it. Mr. A. D. Hall says, in his recent work on "Agriculture after the War": "Where the land is in excess, undoubtedly the maximum

production and profit per man is to be obtained by farming wide areas in the cheapest way possible ; as soon as the amount of land and not the number of men becomes the limiting factor intensive agriculture is necessary." When the latter condition was reached in large parts of India in the second quarter of the last century, the attention of the Government was naturally directed to the more obvious and immediate problems connected with it. Irrigation works on a large scale were initiated about 1850, with the construction of the Ganges Canal, and the policy then adopted has been consistently maintained and developed ever since. Already the area irrigated from State-works fed from rivers or storage reservoirs approaches twenty million acres, and large schemes are still under contemplation to be taken in hand as soon as permitted by the exigencies of finance. During the last decade the State has also materially assisted the peasantry in sinking wells and utilizing "the smaller sources of surface-water, minor rivers, streams, and lakes." Another problem to which the Government addressed itself in the early stages of the evolution of its agricultural policy was to secure a satisfactory tenant-right for the actual cultivators of the soil. The legislation of 1859 was the precursor of a long and progressive series of enactments on the subject, and there is no indication yet that finality in this matter has been reached.

The necessity of a more active and more comprehensive agricultural policy was first realized by Lord Mayo, whose Irish experience no doubt assisted him in appreciating the requirements of India in this respect. But his premature death caused the postponement of a definite agricultural programme until attention was again called to its urgency by the famine that devastated large parts of India during the Viceroyalty of Lord Lytton. Following the recommendations of the Famine Commission of 1880, the Imperial as well as the Provincial Governments organized agricultural departments, of which the main duties were to be "agricultural inquiry, agricultural improvement, and famine relief."

The departments were organized, but there were very few officers to man them. The study of agriculture as a science was in its infancy even in Europe and America. In India, owing to the

vast areas, the diversity of conditions, and the lack of definite knowledge of these conditions, it would indeed have been futile to embark on any large schemes of "agricultural improvement" according to preconceived plans. Under the able direction of Sir Edward Buck, the first Secretary to the Government of India in the Agricultural Department, the agencies organized by the Provincial Governments wisely confined their energies to "agricultural enquiry," *i.e.*, to the collection of reliable statistics extending over a period of years, and to the investigation of indigenous methods and processes of agriculture in different parts of the country. A notable event of this period was the publication in 1892 of the report of Dr. Voelcker, an eminent authority on English agriculture, who had been employed by the Government of India to study Indian conditions. This report, as well as the investigations of their permanent staff, enabled the Government in the middle nineties to formulate a more definite and useful programme of agricultural improvement, but men and money were still lacking. These indispensable requisites, made available only after the report of the Famine Commission of 1901, further emphasized the urgency of an active and many-sided policy of agricultural improvement. Fortunately in the early years of this century the Indian Exchequer was on a rising wave of prosperity, and Lord Curzon was able to allocate sufficient funds for the initial organization of a State policy of "agricultural improvement." Since then a great deal of valuable and permanent work has been accomplished, and, what is more, the foundations have been laid for a wide and extensive structure of agricultural development.

A full story of the recent activities of the new departments will be found in Mr. Mackenna's "Agriculture in India," and in this article it is possible to refer only in the barest outline to the salient features of the general policy that is being followed. There are three correlated aspects of the problem of agricultural improvement in India. The scientific officers of the department have first to determine with reference to the environment what improvements in the crops and the processes can be effected, and will be "commercially" desirable. Secondly, the farmers and cultivators have to be persuaded to adopt the improvements recommended by the

department. Thirdly, many existing obstacles have to be removed from the path of agricultural progress—*e.g.*, the peasants have to be provided with capital on reasonable terms, the sources of supply of agricultural stock and machinery have to be improved and widened, the organization for the purchase of agricultural requisites and for the sale of the produce has to be practically revolutionized, and, by no means the least formidable task of the State, the actual cultivator of the soil must be assured that he will retain a substantial portion of the additional income arising out of his enhanced exertions.

The various endeavours that are now being directed towards these subsidiary but vital problems connected with the improvement of Indian agriculture will be treated of separately in the *Indiaman*, and need no further reference here. The energies of the agricultural departments have been mainly and rightly devoted to the study and the solution of the first two problems mentioned above.

Agriculture in India is to be distinguished from that of western countries in that attention is devoted almost exclusively to the raising of crops, and not of animals for meat. Moreover, much the larger portion of the crops is grown for the food and domestic consumption of the cultivator and his own family. Commercial crops, such as cotton, jute, sugarcane, hemp and flax, oil-seeds and groundnut, are, however, assuming considerable importance, and one of the problems before the agricultural departments is to secure due attention to these non-food products without, in any way, diminishing the food supply of the population. With regard to food crops, "improvement, without losing those qualities which meet the local taste, is the first problem. But it may be that there is an export demand. If the requirements of the local taste and export trade can be made to agree then the problem is enormously simplified. . . . . . The problem, therefore, is to raise a crop of a quality which meets the demands of the export trade and at the same time satisfies the local taste." The scientific officers of the departments, working on the basis of the statistical information that had been laboriously collected in the eighties and nineties of the last century, have enthusiastically taken up the investigation of the many problems connected with the food and the commercial crops, and as will be

evident from a perusal of the numerous technical publications of the department they have already achieved many notable successes.

With regard to the popularization of the results and conclusions arrived at by scientific investigation, progress is not yet very wide, but the indications are full of promise. The co-operative movement initiated about twelve years ago, simultaneously with the extension of the agricultural departments, was mainly intended to provide facilities for the supply of capital to the agriculturists. The movement has grown and developed much beyond the expectations of its founders. The agricultural departments have wisely resolved to utilize the organization of the co-operative societies for the dissemination of agricultural knowledge in the countryside. Other agencies are also being employed, *e.g.*, periodical shows and exhibitions, agricultural associations, the assistance of intelligent and public-spirited landholders, and a wide network of demonstration farms. With regard to these last-named institutions, the local Governments in India have already adopted the policy advocated by Mr. Hall for English agriculture: "There would seem to be room for the introduction of a new type of instruction in business methods by the setting up of demonstration farms run solely for profit, but which keep a strict set of accounts and make public the costs and results of every part of their work. Such farms are particularly needed in districts where it is desirable to bring about a change in the current routine of farming." Lastly, there is the important question of agricultural education for the classes and the masses. This question is no less difficult and complex in India than it is in this country, and it has to be conceded that the policy of the Government of India in this matter is still in a state of flux. But that the problem is being diligently studied is clear from the conferences on the subject that were held last year, and are being held this summer in India. It is to be hoped that a definite programme will now be formulated and actually adopted in practice, for, apart from the purely agricultural and economic significance of the question, it constitutes a very important element of the larger and more general problem of education in India.

THE ACTION OF COPPER ARSENATE AND ARSENIOUS ACID ON SUGARCANE ROOTS.*

THE Bureau of Sugar Experiment Stations has received the following report from the Entomologist (Mr. E. Jarvis):—

It is satisfactory to be able to state that experiments started at Gordonvale Laboratory last November, with the object of determining the action of copper arsenate and arsenious acid on growing roots of sugarcane, have yielded results of a most encouraging nature, and are now far enough advanced to admit of publication of a few details regarding this research work.

In the first test, with arsenate of copper, short "sets" of "Badila" cane having three buds were planted in common 8-in. earthenware flower pots filled with coarsely sifted red volcanic soil. Pots Nos. 1 to 4 were infected at the rate of 113 lb. of Paris Green per acre, the poison being mixed uniformly with the soil in pots Nos. 1 and 2, but buried in a horizontal layer a couple of inches below "sets" in Nos. 3 and 4.

No. 5 was treated at the rate of 226 lb. of the arsenical preparation per acre, thoroughly mixed with the soil; while Nos. 6 and 7 were untreated controls. These "sets," which were planted on 3rd October, sprouted together, all producing healthy-looking shoots. Six weeks later, when the resultant plants were photographed, the mean height of foliage in Nos. 1 and 2 was found to be 15 in.; in Nos. 3 and 4, 18 in.; No. 5, 27 in.; and in Nos. 6 and 7, 15 in.

Nos. 1 to 5 had produced collectively eight shoots, and Nos. 6 and 7 five shoots, the average height of foliage for the five treated pots being 10 in. as against 7·50 in. for the two controls.

This seems to indicate that cane plants may perhaps derive benefit from absorption by their roots of minute quantities of copper salts; since it is a well known fact that, in many cases, we are able to artificially stimulate plant growth by an application to the soil

---

* Reprinted from the *Queensland Agricultural Journal*, vol. VII, part 2. February 1917.

of weak solutions of copper sulphate. In the above experiment all seven pots received the same measured quantity of water, sufficient to nicely moisten but be wholly absorbed by the earth, thus precluding drainage and possible loss of fine particles of the soil or arsenic. Artificial manure, consisting of a little nitrogen and potash, was given at intervals in the water, each pot receiving exactly the same amount.

The result conveyed by the foregoing figures merely confirms previous opinions with reference to Paris Green stated in last month's report.

The quantity per acre advocated in Bulletin No. 4 of this Bureau—in connection with cane grub control by means of poison baits—was only 8 lb., whereas it appears probable that at least 226 lb. per acre can, if desired, be administered to the soil in this way without causing injury to the cane.

Other experiments with Paris Green yielded results practically identical with that given above, so need not be referred to in detail. I may mention, however, that the cane growing in a number of 7-in. pots is higher at present in those treated with copper arsenate than in the controls, and finest of all in one containing cowpea leaves that had been dusted with the arsenical mixture at the rate of 113 lb. per acre.

This experiment was started on the 1st November, and five weeks later (5th December), foliage in these ten pots averaged about 18 in. in height.

As regards the action of commercial white arsenic, cane "sets" were planted, on 4th October, in half-a-dozen 10-in. flower pots, and when photographed after a lapse of six weeks, the average height of cane leaves in those containing soil, infected at rates of from 100 to 200 lb. of arsenious acid to the acre, was found to be 27·80 in., while in a single pot, used as a control, the height was 26 in. All plants appeared equally healthy throughout the course of this experiment. Outdoor tests were limited to an application of copper arsenate to the roots of two months old plant cane growing near the laboratory, the poison being simply dusted over damp cowpea leaves, which were then buried about 6 in. deep on each side of the stools and 8 in. from the centre of the row. Plants treated in this

way continued healthy and developed in a normal manner. Five weeks later, when the soil was examined, the treated cowpea foliage was easily located owing to its conspicuous green hue, but had, of course, partially decayed. The rainfall experienced during the course of the above test was only 112 points, all of which fell on the 7th instant, about a week after burial of the poisoned leaves.

The primary emergence of our grey-back cockchafer was noted by Mr. J. Clarke, of Highleigh, on the 7th instant, and at Meringa a week later. Several experiments were initiated this month in order to determine approximately the duration of the egg stage of *albohirta* under both normal and adverse climatic conditions.

On the 27th a collection of these beetles was procured from the former locality (Highleigh), and twenty female specimens confined separately in cages of damp soil.

When examined after an interval of four days (twenty-three days after emergence), fourteen out of the twenty beetles had, between them, laid 318 eggs, and the remaining six were constructing earthen chambers in which to oviposit.

Half-a-dozen females derived from the above-mentioned collection, but placed on the same date in cages containing dry soil, did not lay; and ultimately, upon dying, four of them were found by dissection to contain eighty-four full-sized eggs fit for exclusion and varying in individuals from ten to thirty in number. The ovaries of the other two were small and apparently unfertile.

We may, I think, reasonably assume from the foregoing evidence that the simultaneous desire to oviposit manifested by the former batch of twenty beetles was induced by the ideal conditions of soil-moisture artificially provided for them; and, moreover, that the ovary in these insects had in most cases attained full development prior to the date of capture, but oviposition had been purposely postponed owing to abnormal dryness of the soil.

It is hoped to deal more fully with this matter in a later report, but I may state that, apart from any scientific interest they may possess, these investigations have, up to the present, resulted in discoveries of more or less economic value in connection with the control of the egg stage of *Lepidiota albohirta*.

THE IMPORTANCE OF SOIL VENTILATION.*

A VERY instructive article on this subject appeared in the *Agricultural News*, Barbados, of 2nd December, 1916. The writer points out that when considering the composition and structure of a fertile soil, we are apt to overlook the fact that air is a constituent part just as essential as water or plant nutrients. Air supply has never taken definite shape in soil science to the extent water supply or plant-food has, and consequently, an important field of investigation appears to be practically untouched. It is true that drainage in relation to soil ventilation is appreciated, as well as methods of cultivation that go to produce a good tilth, but that does not teach us anything; it gives us no definite clue as to what the roots of different crops require, or whether air supply might not be more scientifically adjusted to suit the roots of different crops and the beneficial bacteria that function under similar conditions in the soil. If, under certain circumstances, it were found desirable, it should be quite practicable to supply the soil with air by more direct means than by cultivation and drainage just as we know it is practicable to supply the soil with plant-food in the form of chemicals instead of relying upon weathering and the decay of organic matter. These considerations suggest a new aspect of land culture, namely, constructive soil ventilation—a definite branch of agricultural engineering associated with drainage.

(In 1908 a Bundaberg sugar-planter spent a great deal of money in draining a large sugarcane field, and after the work was done, no rain came, and neighbouring planters laughed, for no water came through these drains, and they said he had wasted his money. But, as the cane grew, it was noticed that during all the dry weather that season, when everybody's cane was drooping, and scarcely growing

* Reprinted from the *Planters' Chronicle*, dated 12th May, 1917.

at all, the cane on this drained land kept on growing and the canes held up their light-green heads above all other canes in the district, and the crop was nearly double that on the other plantations, although there had been no rain and not a drop of water ran through the drains. The reason was that the moisture from below rose through the warm, well-aired loose soil, and the cane roots went down to meet it, and so they stood the dry weather and grew quickly. —EDITOR, *Q. A. J.*)

Before proceeding to enlarge upon this idea, it will be well to consider what evidence exists to justify it.

The importance of soil ventilation has been brought out prominently by the observations of Howard in India. He has pointed out that crops undoubtedly differ greatly in the amount of air their roots require. In India, for example, gram requires a great deal of air, and only a moderate amount of water. In some parts of the country, the conditions, both natural and artificial, are such that the roots get plenty of air. Here this particular crop thrives, but in other places, where, for instance, irrigation conditions obtain, gram will not grow successfully. Howard maintains that the proper provision of air to the soil is all that is necessary for extending the cultivation of this useful crop. The facts are the same in regard to the cultivation of indigo. This crop is largely cultivated on the higher levels in rice-growing districts. The occasional flooding of these higher levels due to the rise of the rivers is the cause of the low yields obtained in India compared with those obtained under drier conditions in Java.

The two crops just referred to are of course leguminous, and the detrimental effect of insufficient air is partly due to the limited supply of nitrogen available for fixation by the nodules on the roots. But that is only partly the reason; bad aeration has a general retarding influence upon root development. Howard has noticed this even in the case of wheat, which is a crop that can be successfully grown on every heavy land; experiments conducted at Pusa show that the best-grown wheat can be raised only on soil that is well aerated. Lastly, rice, which grows in swamps, is unable to thrive without a supply of oxygen for root development. This is obtained

through the surface film of algæ and other green organisms on these soils. Certain cultural operations after harvest also help to conserve a store of oxygen to the soil subsequent to the arrival of the rains.

Other crops in other parts of the world are equally susceptible to anærobic conditions in the soil. In regard to cotton, we know that this plant thrives best on soils of open texture, and that the principal cause of boll-shedding is root asphyxiation, proved by Balls in Egypt, and fully supported by observations in the West Indies. Cacao is extremely sensitive to clay. That may be because cacao is naturally a deep-rooting plant and the clay offers mechanical resistance to the extension of the roots ; but it is also likely to be due to the fact that a clay soil contains less air than a light soil. It is not merely a clay sub-soil, but a clayey surface soil that has an adverse effect on the growth of cacao.

Coconut trees are very sensitive to inadequate aeration. They will thrive only on land that is well drained either naturally or artificially. No harmful effect is produced on the roots by the presence of water ; coconuts will thrive in saturated soil provided the water is continually moving. This is a very significant fact concerning the physiological importance of soil aeration.

In view of all these facts, which come within the range of observation of the planter himself, it will be admitted that soil aeration demands greater attention than it has received. The significant fact is, that air is the limiting factor to the efficiency of water supply. Beyond a certain point, water is wasted in the soil if it is not aerated.

Turning more particularly to the physiology of roots, it is very desirable to know more concerning their respiration. Respiration has been studied almost exclusively in regard to the parts of the plants above ground and the generalizations have been extended to apply to the roots. But it does not seem justifiable to assume that the manner in which roots breathe under the complex conditions, both chemical and physical, of soil environment is the same, and follows the same laws as those parts of the plants exposed to the comparatively simple environment of the atmosphere. There is probably a difference in the rate of respiration of the roots of certain plants, and as already suggested in this article, the growth of certain

crops might be stimulated by the artificial introduction of air into the soil.

Constructive soil ventilation as an established branch of agricultural engineering presupposes successful researches into the air requirements of roots and soil organisms. The desirable conditions in different cases having been determined, it should then be possible to establish them.

The methods of effecting soil aeration artificially would come within the province of the engineer. Possibly one method would be to lay down porous ventilation-pipes through which air could be introduced, if necessary, under pressure. In orchard cultivation vertical tubes might be introduced near the trees and air pumped down them periodically. In the light of soil aeration better use might be made of soil explosions with dynamite, to aerate clayey sub-soils especially.

Investigation might show that an alteration in the percentage composition of the soil atmosphere would prove advantageous in some circumstances ; for example, a high proportion of oxygen might prove beneficial, or in some cases the removal of an excess of carbon dioxide. There is also the question of the possible value of introducing gases other than those that normally constitute the air of the soil. A matter for speculation is whether liquid air could be usefully employed as a soil fertilizer.

Finally, more might be done to bring about a better state of aeration in certain circumstances by means of methods of cultivation. The forking of orchard soils is still a matter of some controversy, and the true value of this operation requires investigation. The ploughing of the soil in coconut plantations gives good results, but its relation to soil aeration is not generally recognized.

HORSE-BREEDING IN INDIA.*

THE world's wastage of horses, due to the present war, is forcing the Governments of the various portions of our Empire to adopt measures in their respective countries for stimulating the production of horses of a suitable type and standard.

A regular perusal of the *Live Stock Journal* will afford very convincing proof of the keen and active interest which is being shown by all horse-lovers in the stimulation and improvement of the several breeds of horses for which Great Britain has long been renowned. Canada, shortly before the outbreak of war, with great forethought had leased at a nominal rental a very large tract of land in its best horse-breeding district to a company for the purpose of raising horses for the needs of its own and our home army. The Australian Commonwealth last year realized the urgent necessity for action with a view to increasing its output of horses of the right stamp for national needs. A conference, representative of all interests, was held in Melbourne last November, and the outcome of its deliberations was published in India early this year.

Is not this the time for the Government of India to examine seriously the question of the supply of all horses for its military and economic needs, and to determine whether India cannot be rendered less dependent on importations to meet the needs for such animals as this country is capable of producing ?

It may with reason be argued that the Indian climate, conditions of soil, and want of cheap pasture lands militate against the economic breeding of horses and ponies of the stamp required for army purposes, and that, so long as Australia can supply our needs at a reasonable price, there is no necessity to spend comparatively large sums

* Reprinted from the *Englishman*, dated 19th June, 1917.

on what admittedly must be a more or less costly production. So long as the Australian supply is capable of meeting our demands and we enjoy the free and unhindered use of the intervening seas, these arguments have some weight.

Insuring our Supply.

Are we justified in anticipating that these favourable conditions will prevail in all future conflicts—or that our sea trade will not be even temporarily closed down while our Naval Forces are contesting the control of the traffic ? There must indeed be very few, however sanguine, who would answer this question in the affirmative. Admitting, then, that these risks are real and have to be underwritten, we have to consider the cheapest form of insurance. There are only two alternative methods of insuring our supply for war—(*a*) the maintenance in peace of a large reserve by importation, or (*b*) the fostering of a sufficient indigenous production to meet the economic needs of the country and the army during peace, and thus through the civil reserve the larger needs of the army during war. The former method, to adequately safeguard our probable wants in war, would, even if feasible, be very costly. The second alternative must in the long run be the cheaper and contribute materially to the economic well-being of the civil and agricultural population—to say nothing of the immeasurable boon which it will confer by making India independent, for its riding horses, of an oversea supply during hostilities, the effects of the earlier phases of which on our seaborne trade cannot with safety be foretold.

Another very cogent reason for not relying too much on importation of riding horses from Australia is that its output of this class of horse has been declining to a dangerously low level if it is to meet its own needs and the needs of India. It has already failed to meet the full demands made on it from India during the past 18 months ; and if after the war a standing army of any size is to be maintained in Australia, and as is anticipated the export of mares from that country should be prohibited, the supply available for this country will be still further seriously restricted.

Indian Ponies.

There is ample evidence that in past days India possessed several famous breeds of horses, each breed with marked characteristics and true to type. The majority of these breeds were of a small or pony type, famous for their powers of endurance under the most trying conditions, and much prized by their owners. Amongst these breeds, not only famous in the areas of their origin, and from which they generally took their names, but almost throughout India, were the "Deccanis," "Kathiawaris," "Marwaris," and in the Punjab the "Dhanis," "Unmol," and "Kajal." Many of these breeds are known and remembered with respect by the older generation of British Officer still serving in India, and at the present time would be welcomed in our fighting units and transport corps in India and Mesopotamia.

Up to the latter part of the 18th century hardy horses were essential to the almost incessant internecine struggles between the various races and clans throughout India and to other needs of the country; but from that time the progress of law and order, the development of irrigation canals, railway traffic, and motor-cars, have been contributory causes to the decline of horse-breeding for economic purposes, and the Government of India have during the past 120 odd years devoted certain sums annually to the production and improvement of horses, and to help to keep the horse-breeding industry alive for army.

Government Action.

The earliest action of Government in the production, or in encouraging the production, of horses in India dates back to somewhere about the year 1795 by the establishment of the Bengal Studs—notably at Pusa and Buxar and since that year the methods adopted, the areas of operation, and the system of control and administration, have gone through many phases and modifications.

The class of stallions tried have included most specimens of the known light horse breeds of both the West and East—and the captious, destructive critic can doubtless point to many errors of judgment and management—but a careful examination of the more

recent methods of operation and control must carry the conviction that the present generation is profiting by the errors of the past, and that it could, provided more facilities are afforded, do much to remedy those errors.

Errors in Breeding.

The worst error in the opinion of a large school of men, who have devoted much time to the study of horse-breeding in many countries, is the too lavish use which has been made of imported sires of Western breeds. These sires were introduced presumably with the object of increasing the size and substance of the stock up to the standard which Great Britain has educated her sons to deem the essentials of a good hunter or troop horse, but the great difference between the climate and soils of Britain and India seems to have been overlooked, and there is little doubt that the more important qualifications which are absolutely necessary to endure the climatic conditions of this country have been sacrificed for the lesser advantage of mere size.

In the light of past experiments and failures, many of those who are in a position to judge are of the opinion that better value for the money spent in the past on trying to improve horses by the infusion of Western blood could have been obtained in the improvement of pure indigenous breeds by the process of selection. The Ahmednagar Stud which is devoted to the production of stallions of pure Eastern breeds affords the strongest evidence of what can be done by selection and proper mating; a visit to this Stud and an inspection of its pure Arab, Kathiawari, and Marwari stock would convince the most sceptical of the value to India of these breeds.

A careful study of the operations of the "Nagar" Stud convinces the visitor that the Government ought to devise, with the co-operation of the Turf Club, a scheme by which these attractive specimens of Eastern blood can prove their prowess on the turf—not in five furlong races carrying the metaphoric "postage stamps," but at distances over 1½ miles, 9 stone 7 lb. to 10-7 on their backs.

We would then know that we are infusing into the future generation of potential troop horses the essential qualification of "stamina."

Encouraging Breeding.

There is every evidence that the present tendency is to mitigate the errors of the past by encouraging a greater use of pure-bred Eastern sires, and in this connection the Western India Turf Club is to be congratulated on its timely gift to Government of Rs. 30,000 per annum for 5 years to be distributed in 200 premiums to the owners of brood mares which fulfil certain conditions, the first of which is that they must have at least one strain of Arab or Indian country-bred in the last two generations. The other conditions entail the mares being up to a standard in girth, height, and shank measurements, which are considered necessary for these mares when suitably mated to breed a cavalry remount. The mares when awarded a premium must be in foal, or with foal at foot, to a Government stallion.

This form of encouragement is one that must have a very much more direct and early influence on horse-breeding than the offer of large prizes of the turf, which tend sometimes to produce mere galloping machines, often with exaggerated faults of conformation which preclude their subsequent use at the stud with any hope of producing horses for national purposes.

It may be accepted as an axiom that certain climates and soils can best produce and carry a more or less defined stamp of horse, and any attempts at opposing these dictates of nature are bound to lead to failure and disappointment.

The Best Horse for India.

The past history of the indigenous breeds of India and experiments during the last 100 years go to prove that the conditions of climate and soil in India are suited only to the smaller types of hard, wiry horses, and not to the larger types that are produced in north-western countries. These small types can, without sacrifice of the essential characteristics, be improved almost without limit by the

process of selection and up to say 15-1 in height, and would probably prove themselves to be superior, for campaigning in a hard country, to horses of a larger and often leggier type.

Any measures of an adequate nature must entail a very considerably larger expenditure than has ever hitherto been devoted to the encouragement of horse and pony breeding in India—that is if it is ever to be self-dependent for its horse supply—and the present affords a very opportune time to the turf clubs, local administrations, and all lovers of horses for patriotic co-operation with Government in the furtherance of this very important national purpose.

RURAL SCIENCE, INCLUDING SCHOOL-GARDENING.*

BY

R. N. SHERIDAN.

In view of the opinion expressed, at the Agricultural Education Conference held last year at Simla, that information about what is being done in other countries regarding agricultural education, be made a feature of the Journal, the following interesting article has been reproduced.—[Editor.]

Definition of a School-Garden.

A school-garden may be roughly defined as any place near, or attached to, a school in which the pupils are taught to grow and care for plants. It may be only a few yards in extent, or it may cover quarter of an acre or more. Its size is less important than the nature of the work done. In it the pupils learn how to grow plants, to take an active interest in their surroundings, and to become more familiar with what is going on in the plant world. It will easily be seen that the school-garden is practically useful in any rural district, but its true educational value must not be underestimated nor overlooked. The pupils are taught not merely how to work land. They are taught to observe and to think, to use their hands, eyes, and mind in conjunction. Concrete facts are presented, and the pupils are taught to think in realities and not in symbols. Real objects and visible changes are considered in the school-garden where the plants are seen and the processes of growth observed from week to week.

* Reprinted from the *Journal of the Department of Agriculture and Technical Instruction for Ireland*, vol. XVII, no. 2.

EVOLUTION OF THE SCHOOL-GARDEN.

About the year 1695 a German monk discerned the educational value of a garden attached to his orphanage, but it was many years later before ideas as to the utility of gardening in this connection for children received much consideration. However, about the beginning of the nineteenth century gardens and small farms were set apart for the instruction of the younger workmen and sons of labourers on several large estates. Out of this practice grew many farm and agricultural schools in which courses of study were given to the children of farmers and labourers. Gradually a belief arose that something should be done for the children of rural schools in the way of definite instruction with a bias towards matters pertaining to rural life. The reasons were not educational but economic, and were intended to encourage the young to take an interest in their surroundings and to check the emigration from the country to the city.

About 1820 several German States introduced the culture of fruits and vegetables into rural schools. In the year 1869 it was required in Austria and Sweden that, wherever practicable, gardens should be attached to rural schools. During later years France, Russia, Switzerland, England, Scotland, America, and Canada followed the lead in recognizing school-gardening in the curriculum of their elementary schools. In the case of Belgium, courses in horticulture were made compulsory in her elementary schools.

SCHOOL-GARDENING IN IRELAND.

For many years past a certain amount of instruction has been given in various schools throughout Ireland, and in County Limerick an endowment scheme existed, and still exists, by means of which grants are given to enable teachers to provide tools and appliances for garden work. Each year the school-gardens in the county are inspected and prizes awarded for the best kept gardens. The work done in some schools was, however, of a somewhat desultory nature and of comparatively little educational value to the pupils who did not receive a sufficient amount of practice in the various cultural operations.

About the year 1909 the present scheme of Rural Science, including school-gardening, was introduced, and a fair amount of progress has been made with it. Its aims are to awaken in the children an intelligent and living interest in the district immediately surrounding their homes and to teach them to understand the principles of plant growth and their application to agriculture and horticulture. The child begins by studying the life of a plant, its various functional activities, its relation to soil, water, air, light, and other factors that help or hinder it in its growth towards maturity. This is accomplished by direct observation and actual experiment on the part of the pupil who then, in the garden, applies the knowledge acquired to practice of simple observations, such as seed-sowing, planting, watering, etc. In addition, practice is obtained in the care and use of tools and in the preparation and working of soil for plants.

Later the pupils become acquainted with the physical features of the district and distribution of human activities depending on such features, and having acquired a knowledge of the life-history of the plant, they proceed to study its environment and become more familiar with external factors, such as weather, soil, etc., which influence the growth of plants.

The following figures show the progress made in school-gardening in England and Scotland, where the scheme is worked on somewhat different lines to those adopted in Ireland. In Great Britain more attention is paid to the actual raising of crops than to the utility of the subject as an instrument of educational value in rural schools.

	England		Scotland	
	Schools	Pupils	Schools	Pupils
1909-10	1,816	33,195	50	940
1910-11	2,176	39,531	140	2,578
1911-12	2,516	45,479	250	4,401
1912-13	2,780	50,917	380	6,500
1913-14	3,011	56,037	497	9,127

It will be seen that school-gardening has made rapid progress in these two countries. In England, in 1902, there were 387 school-

gardens where instruction was given to 4,357 pupils. In 1915 there were over 3,100 school-gardens in operation out of a total of 19,000 public elementary schools.

In Wales, for the year 1913-14, there were 213 school-gardens, in which 3,719 pupils received instruction.

In 1912 there were 70 school-gardens in Ireland in which about 1,200 pupils received instruction. The number of school-gardens in operation has now increased to 126 in the present year, and the total number of pupils receiving instruction is about 2,600.

School-gardening may be made the basis of a national system of agricultural and horticultural education; and in this country, where very many of the children receive their only education at a National School, it should be made an integral part of the curriculum in rural schools.

AN EXPERIMENT IN RURAL BIAS IN A SECONDARY SCHOOL.*

THE Boys' Intermediate School at Welshpool affords an interesting example of an experiment in rural bias in a Welsh Intermediate School. Recognizing that agriculture was the main industry of the neighbourhood, the Governors, with the concurrence of the Board of Education, decided some years ago to introduce into the curriculum of the school a marked agricultural bias. A special grant from the Board of Education was promised, and the Governors arranged a course that was designed to prepare an intending farmer for farm life, for an Agricultural College, or for a University College, while at the same time affording a suitable preparation for other professions, such as the medical, legal, ministerial, and scholastic.

For the agricultural bias the school was well selected. It is situated between lowland and highland farms; three kinds of sheep (Shropshire, Kerry, and Welsh) are seen around it; the country is sympathetic, and the interest of the Elementary Schools is easily aroused so as to produce active support and preparation. Markets and most agricultural operations also are within reach of the school which possesses a special agricultural room for experiments, a garden, and agricultural plots.

It can be said that the agriculture taught is in itself an awakening and inspiring part of a good general education; the interest and intelligence evoked have an appreciable effect on the mastering of other subjects. But the extension of an agricultural bias to the older subjects of the curriculum has a still wider effect.

The bias is most apparent on the science side of the school. Chemistry becomes the main subject and has outdoor as well as indoor laboratories, but Physics is also taught. Botany becomes

* Extracted from the *Report of the Board of Education under the Welsh Intermediate Education Act*, 1889, for the year 1916.

largely agricultural, and to a slight extent medicinal. Geography taught in the modern way has a bias that is very useful to agriculture. The boys bring anything that attracts them in field, lane, or hedgerow into the school for discussion and explanation. Mathematics takes a bias that makes the subject interesting even to the unimaginative. Manual work is given the right suggestion.

Welshpool children learn languages with more difficulty than children in some other parts of Wales. The new bias will bring life into the learning of languages. In English, well-written books describing nature and wild life can take the place of some of the fiction now read. In Welsh, the most beautiful lyric in a modern language of lyrics is a description of the life of a shepherd on the Berwyn ; one of the most terse and picturesque prose romances is a minute description by a practical farmer of life on an upland Montgomeryshire farm. In Latin, the boys were interested in the descriptions and praise of country life in the Georgics. History ceased to be an uninteresting collection of political facts ; its economic aspect, from the Welsh Cistercians to the development of modern sea power, made it what it can be, the most interesting subject in the curriculum.

The experiment has now been completed and has well served its purpose. It was tried under very favourable conditions : the Governors were sympathetic ; the Headmaster threw his whole energy into the attempt ; the teachers of other subjects readily introduced a bias that made each subject appeal more directly to their pupils. It has demonstrated that a bias is a help to an efficient general education, and not a hindrance. The lessons to be learnt from it are now made available for, and should be taken to heart in, every school in rural Wales in which the curriculum is not that best adapted to the future needs of the pupils. Especially should they encourage the Governors and teachers of schools in the industrial districts, where the attempt has not already been made, to find a bias that will make education more useful and more interesting, and thereby more efficient.

Notes.

INDIAN COTTON COMMITTEE.

THE Government of India, in the Revenue and Agriculture Department, issued the following Resolution on 27th September, 1917 :—

"The question of extending the cultivation of long-stapled cotton in India is one which has frequently engaged the attention of the Government of India. It has again been brought into special prominence as the result of recent investigations by the Board of Trade which have shown the importance in Imperial interests of increasing the production of this class of cotton within the Empire. The Government of India consider it desirable that India should co-operate in the solution of this problem, and they believe that the interests of this country in the matter will be found to coincide with those of Lancashire. It has repeatedly been urged by manufacturers in India that it is of even greater importance to them than to manufacturers elsewhere, that sufficient cotton of long staple should be forthcoming in this country, and that the extension of the growth of improved cotton would react most favourably on the manufacturing industry. There are certain areas in which there is reason to believe that long-staple cotton will give a sufficiently large yield to enable it to be grown at a profit. Here the problem is one mainly of organization. In other areas, which include the majority of the cotton-growing tracts in India, a type of cotton combining yield and quality in sufficient degree to enable it to compete successfully with the prevailing short-staple types does not appear to have been as yet evolved and the question of research will enter largely into the solution of the problem. An extension of the growth of long-staple cotton in the above two cases would, in all

probability, prove of great benefit to the cultivators owing to the higher prices which long-staple cotton commands, provided that the full benefit of these prices can be secured to them by improvements in the system of marketing and by the prevention of the harmful practices of adulteration and damping which have done so much in the past to lower the reputation of Indian cotton. In these circumstances the Government of India have decided that the possibilities of extending the growth of long-stapled cotton in India should be investigated by a Committee constituted as follows :—

J. Mackenna, Esq., C.I.E., I.C.S., Agricultural Adviser to the Government of India	President.
F. Hodgkinson, Esq., Member of the Council of the British Cotton Growing Association	Members.
N. N. Wadia, Esq., Member of the Committee and ex-Chairman, Bombay Millowners' Association ..	
G. S. Henderson, Esq., Officiating Imperial Agriculturist	
W. Roberts, Esq., Principal and Professor of Agriculture, Lyallpur Agriculture College .. .	
H. F. Ashton, Esq., Executive Engineer, Punjab	
F. Noyce, Esq., I.C.S.	Secretary.

"The Committee will examine the work which has been done in the various provinces of India in the establishment of long-stapled cottons. It will report regarding the possibility of the extension of any methods which have led to success. It will investigate the causes of failure where this has occurred, and, if it finds that the failure has been due to agricultural, irrigational, or economic causes or to administrative difficulties, will propose appropriate remedies. It will carry out a detailed study of local conditions in each cotton-growing tract and will enquire into the possibility of improving

existing methods of ginning and *marketing* and also of preventing adulteration and *mixing. It will further report on the possibility* of improving the accuracy of the cotton forecasts and generally of making the statistical information published by Government of greater utility to the cotton trade. Finally, it will submit recommendations in regard to the staff required and the organization necessary for the development of the cultivation of long-stapled cottons in tracts which it considers suitable for that purpose.

"The Committee will assemble at Lyallpur on the 8th October, 1917, and will tour in such parts of India as it may consider necessary. The Government of India trust that Local Governments and Administrations will afford the Committee all the assistance it may require and will comply with any request for information and advice which it may address to them."

The Committee toured from 8th October to 26th November in the Punjab, Sind, the United Provinces, the Central Provinces, and Central India. The following is the second half of the tour programme :—

Lahore ..	.. January 7th—10th.
Lyallpur ..	.. January 11th—15th.
Karachi ..	.. January 17th—21st.
Mirpurkhas ..	.. January 22nd—24th.
Bombay ..	.. January 26th—February 3rd.
Ahmedabad ..	.. February 4th—8th.
Viramgam ..	.. February 9th and 10th.
Barla ..	.. February 11th.
Surat ..	.. February 12th—14th.
Navsari ..	.. February 15th.
Dharwar ..	.. February 17th and 18th.
Hubli ..	.. February 19th and 20th.
Gadag ..	.. February 21st and 22nd.
Nandyal ..	.. February 23rd and 24th.
Guntur ..	.. February 25th and 26th.
Madras ..	.. February 27th—March 4th.
Madura ..	.. March 5th—7th.
Virudupati ..	.. March 8th and 9th.

Tuticorin .. .. March 10th—13th.
Coimbatore .. .. March 14th—17th.
A visit to Hyderabad may be necessary.—[EDITOR.]

***

AMERICAN COTTON IN THE PUNJAB.

IN my note in the July (1917) issue of this Journal the area under American Cotton in the Punjab was estimated at 200,000 acres. This estimate was based on sales of seed. More information being available, the area was returned at 213,000 acres in August. Figures obtained for all areas from the Irrigation Department, at the time of writing (October 4), however, exceed the original estimate of the Agricultural Department in March which was for a sown area of 250,000 acres.

The total area now returned is as follows :—

	Acres
Lower Chenab Canal	137,209
Lower Bari Doab Canal	81,137
Lower Jhelum Canal	35,292
Upper Chenab Canal	7,779
Upper Bari Doab Canal	2,500
Other areas	1,000
TOTAL	264,917

The heavy rains at the end of September caused much damage to flowers which would have become bolls and would be ready for picking by early December. Damage is estimated at 4 annas in the rupee. If the weather in October and November is favourable, a yield of 5½ to 6 maunds per acre may be anticipated. Pickings will start about October 10th at Montgomery and October 15th at Lyallpur. The higher area now returned compensates somewhat for the damage caused by rains and wind. The condition of the crop up to September 10th indicated a heavy yield of 7½ maunds.—[W. ROBERTS.]

***

WILLINGDON DAIRY HERD SALE.

AT Ganeshkhind, Poona, on the 20th September, a very successful sale of surplus stock belonging to H. E. Lord Willingdon's herd of Karachi milk cattle was carried through.

The following were put up for auction :—

4 cows,

6 yearling and 6-quarter bulls,

7 yearling and 2-year heifers,

a total of 17 head which realized Rs. 5,281, giving the splendid average of Rs. 310 per head.

The best price obtained was Rs. 500 for the heifer Yuvrani bought by the Chief of Dhrangadhra (Kathiawar). Yuvrani's dam gave over 4,000 lb. of milk. Two of the yearling bulls got Rs. 350 apiece.

These results must be very encouraging to His Excellency the Governor of Bombay whose strenuous efforts to awaken public interest in breeding pedigree cattle are obviously meeting with success. At the sale it was interesting to see a good turn-out of Indian Chiefs.—[G. S. HENDERSON.]

* * *

RESULTS OF BERSEEM CULTIVATION ON SOME DAIRY FARMS.

THE following summary of the results of cultivation of berseem on the several military farms in the 3rd Lahore Division, during the past season, furnished by the Director of those farms will be read with interest :—

AMBALA, 1½ acres, sown in sandy loam, from 10th to 29th November, irrigated with well water (Persian wheel) and top-dressed between cuttings, yielded five cuttings and produced 94,655 lb. of green fodder, an average of 789 maunds per acre.

(*Note.* This is the first trial of berseem cultivation on this farm.)

FEROZEPUR, 4 acres, sown in September on loam soil, top-dressed with town rubbish and irrigated with well water (Persian wheel), yielded six cuttings and produced 172,155 lb. of green fodder, an average of 537 maunds per acre.

(*Note.* The first cutting was spoilt by weeds.)

JULLUNDUR, 5½ acres, were sown in October ; 3½ acres on sandy loam previously down to grass and unmanured, and 2 acres on manured loam, inoculated. Both plots were irrigated with well water (Persian wheel). The former yielded in five cuttings

102,339 lb. (365 maunds per acre), and the latter 139,007 lb. in five cuttings or 868 maunds per acre; a total yield of 241,346 lb. green fodder, or an average of 546 maunds per acre.

(*Note.* The crop on the $3\frac{1}{2}$ acres of new land suffered from frost, but was saved by premature cutting and a top-dressing of stable litter.)

MULTAN, $10\frac{1}{2}$ acres, sown in October on a loam soil heavily top-dressed with old stable litter and inoculated, and irrigated with well water (Persian wheel), yielded five cuttings and produced 508,107 lb. of green fodder, an average of 605 maunds per acre.

LAHORE CANTONMENT, $36\frac{1}{2}$ acres, sown in October, with chiefly home-saved seed, on loam soil unmanured and irrigated with canal water direct flow, yielded six cuttings and produced 1,595,355 lb. of green fodder, averaging 545 maunds per acre.

(*Note.* 12 acres were only cut three times and left for seed estimated to yield about 3 maunds per acre. Irrigation was very intermittent.)

The following is an abstract of the above operations :—

Station	Area cultivated in acres	Out-turn in lb.	Average per acre in maunds
Ambala	$1\frac{1}{2}$	94,655	789
Ferozepur	4	172,155	537
Jullundur .	$5\frac{1}{2}$	241,346	546
Multan .. .	$10\frac{1}{2}$	508,107	605
Lahore Cantonment ...	$36\frac{1}{2}$	1,595,355	545
TOTAL ..	58	2,611,618	562 *

* Total average.

The total yield is equivalent to 1,165 tons of green fodder, averaging 20 tons per acre.—[G. S. HENDERSON.]

***

PECULIAR MINERAL REQUIREMENTS OF CROPS.

THERE is a prevalent idea that particular plants may require relatively large quantities of comparatively rare elementary substances without which they cannot grow healthily, and that this may in part explain the restricted local occurrence of certain species and the restriction of certain crops to certain areas.

If this be so it is possible that liability of a crop to disease in any particular place, by indicating deficiency of some essential element, may be turned to account as a means of ascertaining such peculiar requirements of crops.

An effort in this direction was made on the Ranchi Farm during the recent monsoon, and though no result was obtained, the publication of this note may lead to suggestions for improvement of the method, which is probably defective.

Groundnuts on the Ranchi Farm have for the last two years been so severely attacked by fungus diseases, even on new land, that the crop has been reduced to less than half of the normal. In order to ascertain whether this failure were due to deficiency of some element in the soil, the ashes of such a weight of leaves, stalks, and nuts as would normally grow on a certain area were mixed with water and applied to one-tenth of that area. The residue was treated with excess of sulphuric acid and applied to another tenth. The treated areas were just as diseased as the rest of the crop.—[A. C. DOBBS.]

***

THE FIVE MOST PROMISING BREEDS OF MILCH CATTLE AND TWO BREEDS OF BUFFALOS IN INDIA.

THE five best breeds of milch cows in India are :—

	Breed	Habitat
1.	Sindi	Sind, more especially in the Karachi District.
2.	Sanhiwal	Montgomery District of the Punjab.
3.	Hansi or Hansi Hissar	Hissar District of the Punjab.
4.	Gir	The Gir Hills of Kathiawar.
5.	Ongole	Southern India, Madras Presidency.

1. Sindi cattle, in common with most breeds, do best in their own locality, but they have been exported as far afield as Poona and do well. Many are sent to Bombay annually.

2. Sanhiwal cattle have spread all over Northern India in the Military Farms Department, and do well in most places.

3. The Hansi does not bear removal from its own district so well as those above mentioned, and although it does well in Cawnpore and Allahabad, it deteriorates rapidly in Jubbulpore and Calcutta.

This breed appears unsuitable for humid climates.

4. Gir cattle are found in Bombay in considerable numbers, and appear to do well in moist climates. They have not been tried on a large scale in the Farms Department.

5. Ongole cattle have not to my knowledge been exported to any extent, and they are known only in Southern India.

Buffalos. The premier breed of buffalos in India is the Delhi or Murrah breed. This animal has been transported successfully all over India, though it undoubtedly excels in the southern part of the Punjab.

Another breed of buffalos which is well known is the Surti breed from Gujarat. This breed does well in Bombay but has not done so well in Poona. It appears that a hot plains district suits this breed best. Indeed, experience seems to indicate that buffalos thrive best in hot dry places. For example, these animals do excellently in the hot rainless districts of Sind, but very indifferently in the humid districts of Bengal.—[*Journal of Dairying and Dairy Farming in India,* July 1917.]

***

ELECTRIC FARMING AND SOME RESULTS.

THE great water-power undertakings in India, such as the Bombay hydro-electric schemes, the Cauvery, and the Kashmir-Jhelum schemes, will have a considerable bearing upon industrial development, and it will be of great interest to those engaged in agrarian pursuits to study the possible benefits of cheap electric power on farms and plantations. Electricity is becoming a very important factor in our industries, and its application to the greatest one of all will be of widespread interest even in this ancient land with its hoary agricultural methods. The British Development Commissioners obtained, some time ago, a grant from the Home Treasury, and have recently taken over Huntington Court Farm, near Hereford, for the purpose of thoroughly testing the use of electricity as an aid to food production. The idea is to discharge electricity from a system of thin wire spread over the areas to be treated. The wire network is supported on insulators connected

to poles with a span of thirty feet or so, between every two supports, and is high enough to enable farming operations to be carried on without interference with the apparatus. A high-tension alternating supply of electricity is used, and this, together with a small transformer of valves for rectifying, and an automatic time-switch for controlling, forms a system less costly than any previously in use. Moreover, it is so laid down as to be practically "fool-proof." The current consumption is not great, and the anticipated increased yield per acre of spring wheat, barley, oats, clover, and certain root crops will be eagerly welcomed. The use of electricity in British agriculture has aroused much interest in scientific farming circles for the last fifteen years, and this latest action of the Government is distinctly helpful. So far back as the seventies of the last century, Professor Lemstrom of Stockholm noticed that plants seemed to thrive better as the result of the electrification of the air around them. Since then it has been repeatedly proved, especially on farms fitted up with the Lodge-Newman apparatus, that cereal crops are markedly increased in yield.

The ratio of increase is even greater in the case of vegetables, potatoes, and artichokes growing to a great size without their edible qualities being at all impaired. In Germany where the use of electricity in agriculture has also been introduced in the hope of securing a greater food-supply, it has been found that in dry weather the electrical discharge does not benefit the crops, so spraying with electrified water has been tried. So far as British agriculture is concerned, the Development Commissioners have set out to give the project a fair trial for a period of not less than three years, and, in addition to employing the highest experts in electricity and farming, are obtaining the supervision of the Board of Inventions and Research.

As to the results of electrifying crops, the British Board of Agriculture has published in its Journal a report of a valuable experiment in electric farming which was carried out at Lincluden Mains Farm, Dumfries, during the year 1916. An acre of suitable ground sown with oats was subjected to electric treatment for eight hundred and forty-eight hours during the season ; an equal acreage in other

portions of the same large field, also sown with oats, was not so treated. When the crops were gathered in, it was found that the yield of grain from the electrified area was 49 per cent. larger than that from the unelectrified portions, while the yield of straw was 88 per cent. larger. At the prices current when the crop was reaped the increased value works out at six pounds seven shillings per acre, thus providing an ample margin of profit after due allowance is made for the cost of the current used, which, at the rate of a penny per Board of Trade unit, would amount to about eleven shillings. Certain observations made at Lincluden Mains would also appear to indicate that the benefit of an electric discharge is not confined to the first year, but may extend to a second year at least. Thus a field which had been electrically treated in 1915 produced a much heavier crop of clover in 1916 than a similar field which had not been so treated. If further observation and experiments show that, in addition to an immediate increase of the treated crop, the electric discharge may also benefit a succeeding crop, it is obvious that the agricultural value of the process is very much enhanced.—[*Indian Industries and Power*, vol. XIV, no. 12, August 1917.]

***

COTTON-SEED OIL INDUSTRY.

At a meeting of the Yorkshire Section of the Textile Institute, Mr. C. W. Leather read a paper on the utilization of waste products, covering many different substances which had previously been regarded as worthless. Referring to cotton-seed oil industry he said :—

"There has been a great revolution within late years in the utilization of the cotton-seed, obtaining most valuable commercial by-products which at one time were allowed to go to waste with the seed in the form of manure. Cotton-seed was garbage in 1860, a fertilizer in 1870, a cattle food in 1880, and a table food and many other things in 1890. The manufacture of cotton-seed oil and all of its resultant by-products furnishes one of the best examples of the development of a business based upon the utilization of a waste product. One of the principal uses of cotton-seed oil is the manufacture of compound—a mixture of lard, oleo stearine, and refined

cotton-seed oil, making a most palatable and economical food. Another product of cotton-seed oil—white cottolene—is a mixture of oleo stearine and cotton-seed oil. This product marks, perhaps, the highest development of cotton oil as a food product. Cotton oil is also used in the making of salad oils, packing sardines in the oleomargarine industry for miners' and cathedral lamps, tempering oils, oils for heavy tool-cutting machines and for mixing with putty. The cheapness of cotton-oil, compared with other fats, as well as its excellent soap-making properties, has caused it to be largely used by soap-makers in America. Cotton-seed oil is used to-day to a great extent by bakers. It is also used as a substitute for olive oil. Chemists and physicians now recognize cotton oil as a high-class food product. —[The *Indian Textile Journal,* May 1917.]

***

COTTON RESEARCH.

THE decision of a great Lancashire firm to set aside £10,000 a year for five years for the purposes of scientific research and education is quite the most robust evidence of faith thus far noted. The Tootal Broadhurst Lee Company's example necessarily makes a mark upon the minds of other leaders in the cotton industry, and it should dispose finally of parsimonious promptings or of inclinations to half-do the work. The business of raising a fund for cotton research has begun, and the programme mapped out for the Research Association includes four principal heads: the collation of reports upon the scientific work already done, the founding "somewhere in the British Empire" of a cotton-growing experimental station, the establishment of laboratories for research into manufacturing processes by men borrowed from other institutions for the purpose, and the foundation of a separate research institute with its own staff of experts. The scheme conflicts with the opinion of those who hold that the universities are the proper custodians of applied as of pure science and the natural guardians of scientific industry. The scheme seems to provide for the employment of assistants of university training, and for the occasional services of members of university staffs. Upon these terms the relations between

institutes controlled by traders and universities under other control may be both intimate and fruitful. The more heavily that manufacturers finance research the more probable it is that they will wish to retain its administration in industrial hands.—[*Journal of the Royal Society of Arts*, dated 31st August, 1917.]

***

COTTON CULTIVATION IN CHINA.

THE *London and China Telegraph* draws attention to a pamphlet dealing with the question of cotton cultivation in China, published by the North China Daily News and Herald, Ltd., Shanghai. In this the question of cotton cultivation in China is dealt with in a very compact and convenient form. It will probably surprise many people to learn that China ranks third among the cotton-producing countries of the world. The average crop of America is between thirteen and fourteen million bales, that of India about four million bales, and that of China is conservatively estimated to be in the neighbourhood of two million bales. Unfortunately there are no statistics concerning the cotton grown in China, so that no positive statement can be made as to the acreage under cotton cultivation. In the usual Chinese fashion there seems to be no order or system. Cotton is planted, say, in a given district, then beans, then cotton again, and so on; but the estimate of production given above is thought to be nearly correct. As the writer of the pamphlet says, if any real effort is to be made to better the quality of Chinese cotton and to increase the yield per acre, it will not only be interesting but most important to know, first of all, the approximate acreage now under cultivation. Such figures, he suggests, could be obtained by the Chinese Department of Commerce, or Agriculture, were those departments of the Government induced to take an interest in the matter, as the information could be got by means of reports from the various *lekin* and tax offices throughout the country. That China could be made the leading cotton-producing country of the world is, he says, no wild statement. Experiments made in the vicinity of Shanghai during the past few years show that the yield per acre can easily be increased threefold simply by

selecting seed, by preparing the land in advance of planting, by the use of bean and other fertilizers within the means and reach of all Chinese farmers, and by properly weeding and caring for the plant from planting time until the plant has matured. The yield per acre could be trebled under ordinary scientific cultivation, and there is practically no limit to the extent to which the acreage might be increased.

What is needed is Government action. The author makes suggestions as to what direction it should take. He states that by using the services of trained cotton experts, and by the wise expenditure of money, the Chinese Government could greatly improve the quality and quantity of Chinese cotton, thereby enriching the country and the people and benefiting greatly the cotton industry as a whole. This could be done by the establishment of Government experimental farms in the various cotton-growing districts of China. By experimental culture and the adoption of plant selection and seed selection, by experimenting with fertilizers, it could be determined which particular plant is best suited to a particular locality—details we need not dwell upon. Although it may be too much to expect that the Government would do so from the very beginning, to carry out the work thoroughly would mean the opening of experimental farms, each of about 10 acres (60 mow), at ten or twelve centres, but if a start were made with half that number much good work could be done. The farms should all be linked together under one system with one head in control, a foreign chief cotton expert, who would have full charge of a cotton culture department of the Department of Agriculture. Every other cotton-growing country in the world has its experimental farms, and China to-day stands alone as the one country that does nothing towards bettering the quality or increasing the yield of its cotton. There is reason to believe, however, that the Government is alive to the importance of the matter. Since last year an American cotton specialist was engaged by the Ministry of Agriculture to start an experimental cotton culture farm. This, at any rate, is a beginning, but how far he has proceeded with his work is not yet known. As the author of the pamphlet observes,

whether the desired end will be attained depends much on the authority given him. If he is given a free hand it is safe to state that some worth-while things will be done; but if he is handicapped, as foreign employees of the Government usually are, with no real authority of his own, the outcome is entirely problematical.—[*Journal of the Royal Society of Arts*, dated 31st August, 1917.]

***

SERVICES RENDERED BY BIRDS TO AGRICULTURE.

In the *Revue Scientifique* for July 14-21, 1917, M. André Godard directs attention to the important services rendered by birds to agriculture. The depredations of insects on cultivated crops, both at home and abroad, he points out, are so serious that it is well that we should realize their extent and the good that is done by truly insectivorous species of wild birds. The opinions of many authorities are quoted, and figures given in support of their various statements, which show that enormous numbers of insects, insect larvæ, and eggs are annually destroyed by birds, which, if permitted to live, would make profitable cultivation impossible. M. Godard is of opinion that although many species may appear to be injurious, they are really beneficial when the nature and quantity of their food are carefully considered. He seems to regard the situation as one in which we must be content to put up with a small amount of damage by birds or absolute disaster due to injurious insects. Whilst fully agreeing with all the author claims for the truly insectivorous species, we must differ from him in regarding the damage done as small, and bearing in mind that the truly injurious species are comparatively few in number, we think that agriculture will best benefit by the elicitation of a thorough and detailed knowledge of their feeding habits and the nature of their food throughout the whole of the year, and the enactment of wise measures for the destruction of such species as are known to be too plentiful. We believe that in France, as in Great Britain, many of the insectivorous species of wild birds have suffered owing to the unrestricted increase of the commoner and injurious species, and the situation is one that will not improve by neglect or by the shutting of one's eyes to the actual facts.—[*Nature*, dated 9th August, 1917.]

A MODEL VILLAGE CO-OPERATIVE SOCIETY.

In the beginning of 1910, one or two members of the Servants of India Society selected Hadapsar village, some eight or nine miles outside Poona, to start a co-operative credit society for the benefit of the poor agriculturists. The original number of villagers at the time of registration of the society slowly grew to 30; and to-day it stands at 161. The members come from all the sections of the village community, and the society is thus truly representative of the various interests residing in the village. The society commenced its operations in April 1910, with the members' capital of roughly Rs. 2,500, supplemented by a Government loan of Rs. 2,000. The by-laws allowed, during the first year, borrowing by the society to the extent of Rs. 8,000, and an individual member could be given a loan up to Rs. 300 only on personal security. To-day the society is authorized to borrow up to Rs. 1,25,000 and can give to an individual member a loan of Rs. 2,000 purely on personal security. The society paid interest at the rate of 6 per cent. during the first year on deposits fixed for one year. Now it has been able to bring it down to 5½ per cent. on fixed deposits for one year, 6 per cent. is allowed on those fixed for two years, and 6¼ per cent. on sums that are fixed for three years and upwards. Loans are given to members at 9⅜ per cent. or half a pice per rupee per month, while some of the poorer members were paying interest to their money-lenders at 18 per cent. on the security of land and the crop. During the first year the amount collected by way of deposits from members and outsiders amounted to Rs. 7,449. How far the society has been able to win the confidence of its members and the general public can be well gauged from the fact that the deposits received by the society last year amounted to Rs. 47,393, which sum is distributed as follows: Rs. 13,203 from men-members; Rs. 3,410 from women-members; Rs. 8,177 from male non-members in the village; Rs. 5,487 women non-members in the same village; and Rs. 17,116 from outsiders.

Women's contribution. The reserve fund during the seven years of transactions amounts to Rs. 11,520, and including this and other items such as deposits, entrance fees, gifts, etc., etc., the

society has at its disposal to-day a capital of over Rs. 1,00,000. An interesting feature of these deposits is to be noted in the fact that about one-fourth of these comes from women including outsiders. An educational fund collected mostly by members for the purpose of affording greater educational facilities to the children of the villagers has been deposited and it now amounts to over Rs. 2,000. Even buried money amounting to nearly Rs. 4,000 has been unearthed by the society. Nearly as much interest as was earned by the society, during the first four years of its existence, was earned by it during the last year only. A sum of Rs. 24,656 has been procured so far, as interest by the society; on this basis it can be roughly estimated that the net gain to the members effected in respect of payment of interest can be roughly put at Rs. 25,000, and including other charges which every borrower has to pay in various shapes, it may be even put at nearly Rs. 50,000.

In all these transactions there has been no loss of a single rupee, members being as a rule prompt in their payments. Most of the loans are short-term, *i.e.*, for 12 months; in a few cases the term of loan is extended to 20 months when the crop of sugarcane of a particular kind is delayed. Thus the working of the society has been extremely satisfactory; and so far there have been no suits in court. Members generally borrow for productive purposes, money being applied to agricultural needs, such as manure, seed, bullocks, agricultural implements, land improvements, fodder, water-tax, land-tax, sinking of new wells and repairing old ones. The members of the society own nearly half the sugarcane area of the village. Improved methods of agriculture are being steadily introduced. Supply of capital at a low rate of interest has also given an impetus to the improvement of agriculture. The area under sugarcane has increased, and 40 acres of these are cultivated according to the methods adopted by Government at the Manjari Farm. Ammonium sulphate, which the people had never heard of before, is now used to the extent of Rs. 2,000 nearly per year. Over 60 ploughs of the modern type have been bought by the villagers, and 10 new wells have been sunk. The work of the society has been done at a considerably low cost, the amount spent last year

was less than Rs. 200, and this included the secretaries' pay, contingencies, etc., while the total turn-over was Rs. 1,59,700.

Lord Willingdon's appreciation. Speaking at the seventh annual meeting of so useful an institution, His Excellency Lord Willingdon said that co-operation was the corner-stone of agriculture and he wished to see as many agricultural co-operative credit societies established in India as possible. The Hadapsar Co-operative Credit Society was one of the model societies of this presidency. There was one point that had struck him rather forcibly, and that was the reference to the desire for litigation inherent in the people. As he saw it in the presidency, that desire had been followed by tragic and serious consequences, and he was delighted to find that through the work of their society they had reduced litigation. They had introduced a spirit of honest rivalry and, as it seemed to him, had fostered in their midst a spirit of co-operation and self-help. He congratulated them on what they had done. His Excellency wished at that stage to give expression to the obligation he felt himself under, to the selfless work and untiring energy displayed by the members of the Servants of India Society. To him it seemed as if the Servants of India Society, of which Mr. Devdhar was a senior member, was never weary of well-doing for the benefit of the people of India. They must bear in mind the fact that if they wished to raise the people of India to a higher plane, they must do whatever lay in their power to better their condition. Unless they could infuse a brighter atmosphere into the homes of the people of India, unless they could help to render those homes more happy, and healthier than they were, they could not expect to uplift the people of the country. It was for this reason he was so pleased to be there that evening. They had started in a very small way as a co-operative credit society, but, as he understood, they had branched out. They now owned their own oil-engine and crusher, and he believed he had now to open the machine for crushing oilcake.

His Excellency hoped that responsible persons would come forward to take a real and particular interest in agricultural co-operation. If they could get up such a spirit throughout the

length and breadth of India they would do an immense amount of good. Political reforms would come, personally he wanted them to come, but unless they raised up a class of citizens capable of giving sound advice to the people of this country, their work would not be well done. His Excellency was perfectly confident that as the society had done so well in the past it would be equally successful in the future.—[*Commerce*, dated 4th October, 1917.]

***

IMPORTANT INDUSTRIAL PROJECT.

MESSRS. TATA AND SONS have, I understand, decided to open a margarine factory at Ernakulam, in the Cochin State, with the respectable capital of about a quarter of a crore of rupees. The Cochin Durbar has not only promised the gift of a site, but also other help. Coconut is one of the principal agricultural products of the West Coast, especially of that region known as Kerala, which comprises British Malabar, Cochin, and Travancore. The great bulk of this produce is exported to foreign markets, especially Europe, either in the form of dessicated nuts or in the shape of oil extracted from it. *Punack*, which is the refuse left, is also exported largely to the Continent. The oil and dessicated nuts are converted into margarine and soap, and the oilcake is used for cattle food. There are a number of oil-mill concerns working in Cochin, Calicut, Ponnani, Alleppey, Quilon, Trivandrum, and Shertally. The mills are all worked by power, and total well into four figures, but the expressers are mostly of the rotary type and similar to the country *chucks*. The larger concerns are mostly owned by the capitalists from Bombay, and the trade, as it stands, is in a flourishing condition. Messrs. Tata and Sons' endeavour to treat the raw material and export the manufactured product is certainly to be commended, but if the effect of it will be to destroy competition and thus conduce to the ultimate reduction in the price of the raw product, the Malabar producer will not have much to be thankful for. There is, however, no room for despair on this head, because if, along with the manufacture of margarine, a coconut yarn and fibre factory is also started for dealing with coconut husk, the combined concern can pay an excellent dividend even after

paying a higher price for the raw material than what the market values of coconuts were before the war.—[*Commerce*, dated 4th October, 1917.]

***

MALARIA AND AGRICULTURE.

A NATIONAL institute is to be established in Italy having for its objects the investigation of the relations between malaria and agriculture, the study of the direct and indirect causes of the unhealthiness of malarial districts, and the organization of a campaign against those causes.—[*Nature*, dated 4th October, 1917.]

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

Dr. W. H. Harrison, Agricultural Chemist, Madras, has been appointed Imperial Agricultural Chemist, Pusa. He took over charge on the 10th November, 1917.

***

The designation of Imperial Bacteriologist, Muktesar Laboratory, is changed to Director and First Bacteriologist, Muktesar Laboratory.

***

Mr. A. W. Shilston, M.R.C.V.S., returned from military duty and assumed charge of the post of Second Bacteriologist, Muktesar Laboratory, on 9th October, 1917.

***

Lieut. E. C. Bowes, Army Veterinary Corps (Special Reserve), has been appointed to officiate as Pathologist, Muktesar Laboratory, with effect from 9th October, 1917.

***

The services of Mr. S. E. Andrews, Engineer, Muktesar Laboratory, were placed at the disposal of the Railway Board, for a period of two weeks, with effect from the 12th October, 1917.

***

Mr. D. T. Chadwick, I.C.S., who has been appointed the first Indian Trade Commissioner in London, assumed charge of his duties on the forenoon of the 8th October, 1917.

***

M. R. Ry. M. R. Ramaswami Sivan, Avargal, Senior Assistant in Chemistry, Madras, has been appointed to act as Government Agricultural Chemist in place of Dr. W. H. Harrison appointed Imperial Agricultural Chemist.

THE Hon'ble Mr. G. F. Keatinge, C.I.E., I.C.S., Director of Agriculture and of Co-operative Societies, Bombay Presidency, was granted privilege leave for one month from 1st October, 1917.

***

DR. HAROLD H. MANN, Principal, Agricultural College, Poona, was appointed to act as Director of Agriculture and Co-operative Societies, *vice* the Hon'ble Mr. G. F. Keatinge on leave.

***

MR. J. B. KNIGHT, M.Sc., Professor of Agriculture, Agricultural College, Poona, held charge as Principal in addition to his own duties, *vice* Dr. Harold H. Mann acting as Director of Agriculture and Co-operative Societies.

***

MR. T. F. MAIN, Deputy Director of Agriculture in Sind, has been granted three months' privilege leave with effect from the 6th October, 1917.

***

DR. W. BURNS, Economic Botanist, Bombay, has been transferred to the Indian Army Reserve of Officers as a Lieutenant and attached to the 114th Mahrattas.

***

MR. S. L. AJREKAR, B.A., Assistant Professor of Mycology at the Agricultural College, Poona, has been appointed to act as Economic Botanist to the Government of Bombay, *vice* Dr. W. Burns, permitted to join the Indian Army Reserve of Officers.

***

MR. G. S. KULKARNI, L. Ag., Assistant Mycologist under the Economic Botanist to the Government of Bombay, has been appointed to act as Assistant Professor of Mycology at the Agricultural College, Poona, *vice* Mr. S. L. Ajrekar appointed to act as Economic Botanist.

***

MR. B. C. BURT, B.Sc., Deputy Director of Agriculture, United Provinces, is placed on special duty under the Munitions Board of the United Provinces.

PANDIT NAND KISHORE SHARMA, Divisional Superintendent of Agriculture, Central Circle, United Provinces, has been appointed to officiate as Deputy Director of Agriculture, Central Circle, Cawnpore, *vice* Mr. B. C. Burt on special duty.

***

MR. F. H. VICK, Agricultural Engineer, Cawnpore, was granted privilege leave for five weeks, with effect from the 12th September, 1917.

***

MR. A. W. FREMANTLE, Special Officer in charge of Ravine Reclamation, U. P., has been granted extraordinary leave without allowances for one month in continuation of that already granted to him.

***

DR. R. J. D. GRAHAM, Economic Botanist, Central Provinces, has been appointed a Second-Lieutenant and posted for duty under the Deputy Director of Agriculture, Mesopotamia Expeditionary Force.

***

MR. C. P. MAYADAS, M.A., B.Sc., who has been appointed to the Indian Agricultural Service on probation by the Government of India, is appointed to be Assistant Director of Agriculture and posted to the Southern Circle, Central Provinces.

***

MR. R. BRANFORD, M.R.C.V.S., I.C.V.D., Superintendent of the Government Cattle Farm, Hissar, is posted to Hissar, from 2nd August, 1917, on return from leave, relieving Captain R. Morris who reverted to his substantive appointment of Deputy Superintendent, Government Cattle Farm, Hissar, on the same day.

***

MR. A. C. DOBBS, B.A., Deputy Director of Agriculture, Chota Nagpur Circle, was granted privilege leave for fourteen days from the 15th November, 1917.

***

MR. B. A. COLLINS, I.C.S., Registrar of Co-operative Societies, Bihar and Orissa, is appointed Controller of Munitions, Bihar and Orissa Circle, under the Indian Munitions Board in addition to his other duties.

THE services of Temporary Captain G. C. Sherrard, Supply and Transport Corps, formerly Deputy Director of Agriculture, Bihar and Orissa, have been brought to the notice of the War Office by the late Sir Stanley Maude, Commander-in-Chief, Mesopotamia Expeditionary Force, as deserving of special mention.

***

THE Bengal Provincial Co-operative Conference at its last sitting recommended that power should be given to co-operative societies to bring non-transferable occupancy holdings to sale for debts payable by members. It is understood that the question of the transferability of occupancy holdings will shortly be taken up by the Local Government who have appointed a Committee to deal with it in all its aspects.

***

AT the instance of the Government of His Highness the Maharaja of Mysore, a Conference to consider questions connected with the "spike" disease of sandal wood, which is responsible for an annual loss of Rs. 6 lakhs to the State, was held in Bangalore from the 4th to the 6th October, 1917. The Conference was presided over by Dr. Coleman, Director of Agriculture, Mysore, and the Governments of India, Madras, Coorg, and Mysore were all represented. The object of the Conference was to establish a certain amount of co-ordination among the various workers on the "spike" disease.

***

WITH a view to prevent the spread within the State of any plant disease the Mysore Legislative Council passed on 30th September last a Destructive Insects and Pests Act which empowers Government to declare any specified area or locality to be an infected area in respect of a certain crop and to order seizures, inspection, disinfection or destruction of any crop in an infected area or of crops in contact or proximity thereto. Provision has been made for compensating the owners of crops destroyed by order where the crops so destroyed are not themselves infected. A breach of a rule under the Regulation makes the offender on conviction by a Magistrate liable to a fine not exceeding Rs. 500.

The Magistrate has, however, been given the discretion of discharging a first offender with a warning. The Regulation has received the assent of the Maharaja.

***

WAR SERVICES OF OFFICERS OF AGRICULTURAL AND VETERINARY DEPARTMENTS.

THE following is the list of officers of the Agricultural and Veterinary Departments who have been or are on war service :—

Imperial Department of Agriculture in India.

Messrs. J. Walter Leather and J. H. Walton, and 8 Indian assistants.

Imperial Bacteriological Laboratory, Muktesar.

Drs. R. V. Norris and G. H. K. Macalister, and Mr. A. W. Shilston.

Provincial Departments of Agriculture.

BENGAL	Messrs. K. McLean, P. J. Kerr, and A. D. MacGregor, 10 Veterinary Assistants, and 1 Laboratory Assistant of the Bengal Veterinary College.
BIHAR AND ORISSA ..	Messrs. E. J. Woodhouse, N. S. McGowan, and G. C. Sherrard, and 3 Veterinary Assistants.
UNITED PROVINCES	Dr. A. E. Parr, Messrs. G. Clarke, W. N. Harvey, R. D. Fordham, W. S. Smith, and T. S. Davies, and 17 Veterinary Assistants.
PUNJAB	Messrs. H. Southern, H. E. Cross, D. Meadows, and W. A. Pool, and 2 Veterinary Inspectors and 38 Veterinary Assistants.
BOMBAY ..	Messrs. T. Gilbert, W. Burns, E. S. Farbrother, and K. Hewlett, and 12 Veterinary Assistants.

MADRAS	Messrs. E. Ballard and Roger Thomas (Cotton Work in Mesopotamia), and 1 Veterinary Inspector and 5 Veterinary Assistants.
CENTRAL PROVINCES	Dr. R. J. D. Graham, Messrs. J. H. Ritchie and F. J. Plymen, and 3 Veterinary Inspectors and 16 Veterinary Assistants.
ASSAM	Mr. A. G. Birt, and 7 Veterinary Assistants.
BURMA	Colonel G. H. Evans, Major T. Rennie, and Mr. C. J. N. Cameron.
N.-W. F. PROVINCE ..	7 Veterinary Assistants.

The following officers have been appointed as Recruiting Officers or their services have been placed at the disposal of the Indian Munitions Board :—

Hon. Mr. C. A. H. Townsend, Director of Agriculture, Punjab.
Mr. C. G. Leftwich, Director of Agriculture, C. P.
Mr. B. C. Burt, Deputy Director of Agriculture, U. P.
Mr. G. Evans, Deputy Director of Agriculture, C. P.

TENTH MEETING OF THE BOARD OF AGRICULTURE IN INDIA.

THE Tenth Meeting of the Board of Agriculture in India was held in the Council Hall at Poona from the 10th to 15th December, 1917. It was attended by 90 members and visitors. His Excellency Lord Willingdon, Governor of Bombay, presided over the opening meeting which was also addressed by the Hon'ble Sir Claude Hill, Member in charge of the Revenue and Agriculture Department of the Government of India. A full account of the meeting, together with a photograph of the Board, will appear in the April Number of the Journal.

Reviews.

Note on Cattle in the Bombay Presidency.—By the Hon'ble Mr. G. F. KEATINGE, C.I.E., I.C.S., Director of Agriculture, Bombay. Bulletin No. 85 of the Department of Agriculture, Bombay. Price As. 11 or 1*s*.

MR. KEATINGE has written a very painstaking account of the cattle found in Bombay. The report deals with the general and economic considerations of the question of cattle and cattle breeding, and is well worth the careful study of any one interested in this most important agricultural question. The subject is dealt with under the following heads :—District cattle censuses for the years 1886 to 1911 : a note on the principal breeds of cattle and their breeding grounds : a general account of the conditions under which cattle are bred : a detailed account of the breeding grounds and conditions : fodder : breeding : economic side of the question : milk and meat : general recommendations.

There are also some very good maps accompanying the report, which add greatly to the clearness of the subject matter. The tracts where the different breeds are found are marked on these maps ; though, of course, it is to be understood that in many places the different breeds so overlap that it is impossible to say definitely where one begins and the other ends.—[G. S. H.]

***

The Fruit Garden in India (in English and Urdu).—By Babu CHATER SEN DIGAMBRI, Head Clerk, Government Botanical Gardens, Saharanpur. Printed at the Mufid-i-Am Press. Price R. 1-8.

THIS book deals with the culture of common fruit trees in the plains as well as on the hills, and contains general information and

instructions on the following points :—(1) How to lay out a fruit garden ; (2) Seasons of fruiting : Suitability of soil ; (3) Time and Method of Planting ; (4) Planting distance ; (5) Preparation of ground ; (6) Manuring ; (7) Pruning ; (8) Watering ; (9) Propagation ; and (10) How to improve fruit trees that yield unsatisfactorily or show stunted growth.

Though the information contained in the book is scrappy and there are many inaccuracies in printing, we think that this bilingual publication has filled a distinct want and should prove of some value to those interested in the cultivation of fruit trees, especially in Upper India, and to those in charge of District Board gardens and nurseries.—[EDITOR.]

Correspondence.

NOT ENOUGH TO EAT?

To the Editor,

The Agricultural Journal of India.

Sir,

The article entitled "Not Enough to Eat?" in your October issue was perhaps reprinted from the *Indiaman* in order to invite comment.

To say that at any given moment there are *some* people in the world who have not enough to eat, and to ask what would happen if this were true of *everybody* is to suggest an impossible contrast. An "Old Settlement Officer" must be aware that even before the war and in England not only some people, but a very large proportion of the population was habitually underfed, and no probable shortage of food production can cause more than a moderate increase in the proportion of underfed throughout the world, while many will continue to eat too much.

It is in fact primarily a question of distribution, and if the British Government is not already alive to the necessity of devoting almost the whole of its energies immediately after the war to the increased production of shipping, an "Old Settlement Officer" will, no doubt, urge it upon them both as an obvious use for the enormous amount of labour and machinery now employed in making munitions, etc., and with a view to cheapening food in Europe, assisting emigration, and generally accelerating the establishment of new normal conditions.

It is no doubt right that the question of food supplies should be urged upon the Government of India, but the specific remedy suggested is hardly worthy of an "Old Settlement Officer," who must be aware that the direct method of increasing the acreage of food *grains* is not the best method of increasing the food *supply*.

To begin with, such an arbitrary disturbance of systems of cultivation would upset the distribution of labour over the agricultural year and cause bad cultivation and a decrease in total output. Then again "food grains" are not necessarily or even obviously the most economical food crops.

One of the best methods of meeting such a crisis as is anticipated, would be to increase the consumption of animal food in Europe by high feeding of the available livestock—the females for milk production and the males for early fattening. Such high feeding can be most economically contrived by supplementing the by-products of food growing at home with the by-products of two of the great groups of crops grown in India for export—cotton and oilseeds. The value of the best oilcakes in England is normally about the same as that of wheat, while oil in the form of margarine is about three times as valuable as wheat as a human food, so that the substitution of wheat for oilseeds in the limited shipping space available would hardly be economical.

The export of oilseeds will in fact meet two of the most urgent food requirements of Europe without upsetting the really very delicate equilibrium of the Indian cultivator's economy.

As regards cotton, it is not suggested that the production of cotton seed should be increased, but the substitution of food grains for cotton in pure cotton tracts would probably result in little, if any, increase in the net food supply, and would mean an enormous loss to the cultivator.

What does really seem to be required is an all-round intensification of production in India such as can be best effected by the raising of prices of agricultural exports at the earliest possible moment. If shipping be not available early in 1918, something might be done by buying up oilseeds and wheat immediately after harvest, from January to May, or by encouraging reasonable

speculation in these commodities at that time, so as to ensure that the cultivator would realize the demand in time to make his own arrangements for increasing their acreage before the monsoon.

Some system of publishing current market prices throughout the monsoon might also be developed, so that when the time comes, the cultivator may decide whether wheat or oilseeds, which to some extent compete in Northern India for the same land, will pay him best.

Yours faithfully,

GROUNDNUTS.

October 19, 1917.

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS.

1. Wallis Hoare's Veterinary Therapeutics. A Guide to the Treatment of Disease in Domestic Animals. New (Third) Edition. Pp. xxiv + 943. Price 18*s*. net.
2. Hutyra and Marek's Special Pathology and Therapeutics of the Diseases of Domestic Animals. Second Edition. Pp. xxxiv + 2321. With Coloured Plates and 438 Illustrations in the text. Complete in two volumes. Price £3 10*s*. net.
3. Chemistry in the Service of Man, by Professor A. Findlay. Second Edition. Pp. xv + 272. (London : Longmans & Co.) Price 6*s*. net.
4. Technical Handbook of Oils, Fats and Waxes, by P. J. Fryer and F. E. Weston. Vol. I.—Chemical and General. Pp. x + 279 + xxxvi Plates. (Cambridge University Press.) Price 9*s*. net.
5. On Growth and Form, by D'Arcy Wentworth Thompson. Pp. xv + 793. (Cambridge University Press.) Price 21*s*. net.
6. Principles of Plant-Teratology, by W. C. Worsdell. Vol. II. Pp. xvi + 296 + Plates 26—53. (London : The Ray Society.) Price 25*s*. net.
7. Plants Poisonous to Live-stock. Pp. vi + 119. (Cambridge University Press.) Price 6*s*. net.
8. The Theory and Use of Indicators : An Account of the Chemical Equilibria of Acids, Alkalies, and Indicators in Aqueous Solution, with applications, by Dr. E. B. R. Prideaux. Pp. vii + 375. (London : Constable & Co., Ltd.) Price 12*s*. 6*d*. net.

9. The Nutrition of Farm Animals, by Henry P. Armsby. Pp. xvii + 743. (London: Macmillan & Co., Ltd.) Price 11*s*. net.
10. Composition and Nutritive Value of Feeding Stuffs, by T. B. Wood. (Cambridge University Press.) Price 1*s*. net.
11. Regional Veterinary Surgery and Operative Technique, by Jno. A. W. Dollar, M.R.C.V.S. Pp. 1115 + 584 blocks. (Edinburgh: David Douglas.) Price 25*s*. net.
12. The Anatomy of the Horse: A Dissection Guide, by Sir John M'Fadyean. Second Edition; completely revised. (London and Edinburgh: W. & A. K. Johnston, Ltd.) Price £1 4*s*.
13. Microscopic Analysis of Cattle-foods, by T. N. Morris. Pp. viii + 74. (Cambridge University Press.) Price 2*s*. net.
14. Farm Forestry, by Prof. J. A. Ferguson. Pp. viii + 241. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd.) Price 6*s*. net.
15. Soil Conditions and Plant Growth, by Edward J. Russell, D. Sc. (Lond.), Director of the Rothamsted Experimental Station. Third Edition: Revised and Enlarged. (London: Longmans, Green & Co.) Price 6*s*. 6*d*. net.
16. Manual of Fruit Diseases, by L. R. Hesler and H. H. Whetzel. (London: Macmillan & Co.) Price 8*s*. 6*d*. net.
17. Name this Flower: A simple way of finding out the names of common plants without any previous knowledge of Botany, by Prof. G. Bonnier. Pp. xii + 331 + Plates 64. (London: J. M. Dent and Sons, Ltd.) Price 6*s*. net.

THE following publications have been issued by the Imperial Department of Agriculture in India since our last issue:—

Memoirs.

1. On a Collection of Sphecoidea sent by the Agricultural Research Institute, Pusa, Bihar, by Rowland E. Turner, F.Z.S., F.E.S. (Ent. Series, Vol. V, No. 4.) Price As. 12 or 1*s*.

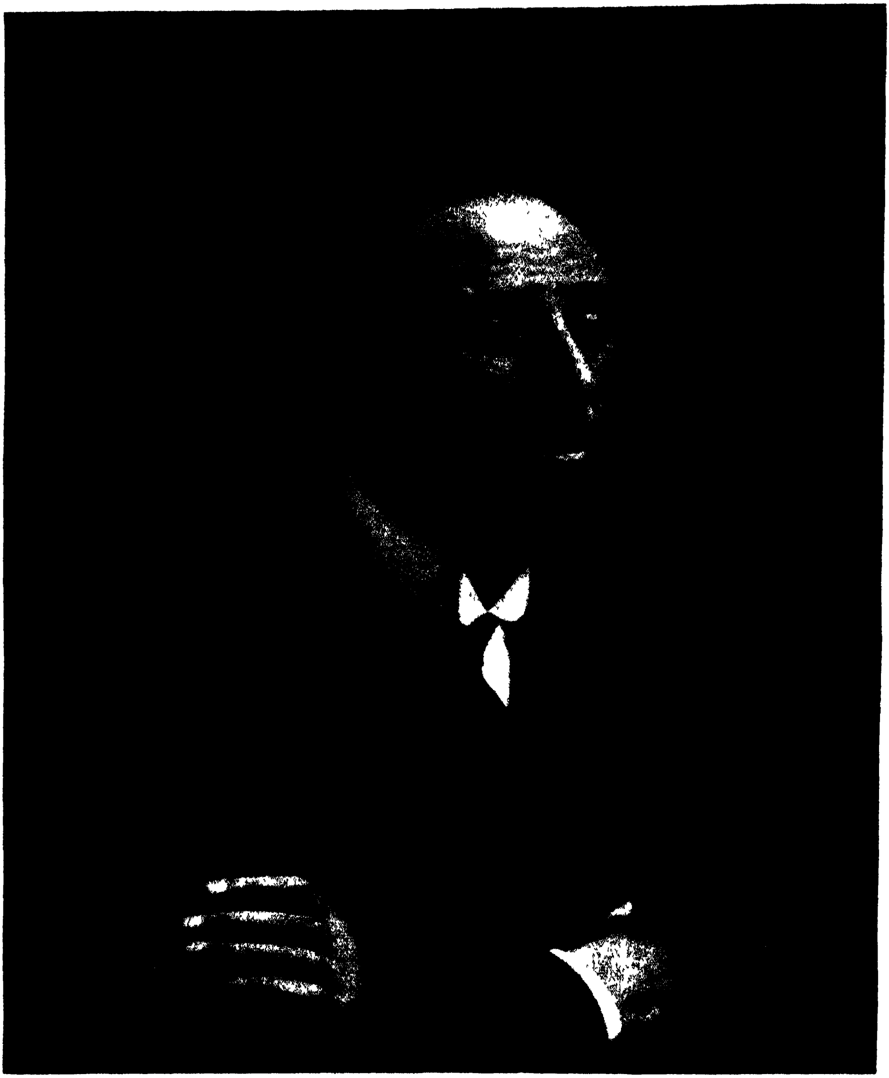
2. The Vitality of the Rinderpest Virus outside the Animal Body under Natural Conditions, by A. W. Shilston, M.R.C.V.S. (Vet. Series, Vol. III, No. 1.) Price As. 12 or 1*s*.

Bulletins.

1. The Composition of some Indian Feeding Stuffs, by Jatindra Nath Sen, M.A., F.C.S. (Bull. No. 70.) Price As. 10 or 1*s*.
2. Water Hyacinth (*Eichornia crassipes*): Its Value as a Fertilizer, by R. S. Finlow, B.Sc., F.I.C., and K. McLean, B.Sc. (Bull No. 71.) Price As. 5 or 6*d*.
3. A Note on Jhooling in Camels, by H. E. Cross, M.R.C.V.S., D.V.H., A.Sc. (Bull. No. 72.) Price As. 2 or 3*d*.
4. New Agricultural Implements for India, by G. S. Henderson, N.D.A., N.D.D. (Bull. No. 73.) Price As. 3 or 4*d*.
5. Experiments with Emulsions for Protecting Camels against the Attacks of Blood-sucking flies, by H. E. Cross, M.R.C.V.S., D.V.H., A.Sc. (Bull. No. 76.) Price As. 2 or 3*d*.

Reports.

1. Proceedings of the Mycological Conference held at Pusa on the 5th February, 1917, and following days. Price As. 2 or 3*d*.
2. Scientific Reports of the Agricultural Research Institute, Pusa (including the Report of the Imperial Cotton Specialist). Price As. 9 or 10*d*.



J. MOLLISON, C.S.I., M.R.A.C.,
First Inspector-General of Agriculture in India.

Original Articles.

RAINFALL, IRRIGATION AND THE SUBSOIL WATER LEVEL OF THE GANGETIC PLAIN IN THE UNITED PROVINCES OF AGRA AND OUDH.

BY

C. H. HUTTON, M.I.C.E.,

Lately Chief Engineer, P.W.D., Irrigation Branch, U.P.

IN the January (1917) Number of this *Journal* Mr. E. A. Molony, I.C.S., calls attention to the great importance of well irrigation in the United Provinces, and in support thereof gives figures to show that nearly 58 per cent. of the total area irrigated is from wells; he also states that the increase in well irrigation, due to the very considerable activity displayed for a good many years past, more especially since the severe famine of 1896-97, both in the construction of new wells and in the improvement of existing wells by boring, has been as much as 52 per cent.

In connection with these facts and in view of the very general complaint heard of late years that the ground-water level is seriously falling, he raises the question as to "whether the underground water supply can stand permanently the existing drain on it, to say nothing of the much greater drain which the vigorous construction of wells, the systematic boring of existing wells, the sinking of modern tube wells of large diameter, and the introduction of mechanical power for lifting water are likely to impose." After discussing the problem he comes to the conclusion that, owing to the increased draught on the subsoil water from the increase in the

number of wells, and also to the more economical distribution of canal water, " the net annual addition to the subsoil water supply is now considerably less than it was 20 years ago," and he concludes from this " that there is a permanent tendency towards a fall in the subsoil water level."

Finally, he suggests certain possible remedies or palliatives to counteract this tendency. A permanent fall in the water level of 10 feet or more would no doubt place out of action or seriously reduce the inflow of a large number of existing *kutcha* and *pucca* wells since, for the most part, they are sunk to no great depth below the subsoil water level.

The question, therefore, which Mr. Molony raises, is of such great importance to the agricultural prosperity of these provinces, more especially of Oudh which at present is without canal irrigation, that I may perhaps be excused if I endeavour to throw further light on the subject.

In order to show more clearly the expansion of irrigation which has taken place within the last 20 years, instead of taking the whole of the Provinces as Mr. Molony has done, I have selected two tracts :—

(1) The canal-irrigated tract in the province of Agra, comprising the districts of Saharanpur, Muzaffarnagar, Meerut, Bulandshahr, Aligarh, Muttra, Agra, Etah, Mainpuri, Farrukhabad, Etawah, Cawnpore, Fatehpur, and Allahabad. All these 14 districts are irrigated from one or other of the canals—Ganges, Lower Ganges, Eastern Jumna, and Agra. This latter canal also irrigates in the Delhi and Gurgaon districts outside these provinces.

(2) The well-irrigated tract in Oudh, comprising the 11 districts of Shahjahanpur, Pilibbit, Lucknow, Unao, Rae Bareli, Sitapur, Hardoi, Kheri, Sultanpur, Partabgarh, and Barabanki, all of which lie in the Ganges-Sarda Doab. These districts have been selected as being those, with possibly one or two exceptions, into which irrigation by means of a canal from the Sarda river is likely to be introduced in the near future : this tract is moreover typical of the best well-irrigated part of these provinces.

I have also selected for comparison the famine years of 1896-97 and 1907-08 for the reason that, in years of such severe drought as

these, the utmost use is made of all possible sources of irrigation, and a comparison therefore offers the best possible index of the increased measure of protection against famine afforded by the extension of canal and well irrigation. The climatic conditions in both these years were very similar. In the canal and well-irrigated tracts the total rainfall in 1896-97 was 16·8 and 22·4 inches, and in 1907-08, 17·26 and 20·86 inches respectively. The monsoon of 1896 began on 15th June and ended on 27th August: in the following cold weather 0·2—0·6 inch of rain fell in November, 0·2—1·0 inch in December, and about the same amount again in January. The monsoon of 1907 began during the third week of July and ended in the last week of August; in the following winter some useful showers fell in January and February. Although the total rainfall of each year was practically the same, the monsoon of 1907 lasted only five weeks and the following winter rains were not only later but smaller in amount so that on the whole it may be said that the drought of 1907-08 was the more severe from an agricultural point of view.

The Canal-irrigated Tract.

Table I (pp. 204-5) gives the agricultural and irrigation statistics of this tract for 1896-97 and 1907-08.

The Agricultural Department's records for 1896-97 do not show the total area irrigated. This has been interpolated by me in the following manner: the total canal-irrigated area is known from the Irrigation Department's records and an addition equivalent to a percentage derived from the figures for 1907-08 has been made to the total *ek-fasli* area irrigated from wells and other sources; the two added together give the total area irrigated during the year very approximately.

Comparing the *ek-fasli* figures for irrigation from wells and other sources, since there is unfortunately no record of the corresponding *do-fasli* figures, we find that in 1907-08 well irrigation decreased by 0·2 per cent.; this is somewhat surprising if the figures for the number of wells available in each year be compared. The well figures for 1896-97 are not, however, believed to be very accurate

and the number of wells actually in use has not been recorded. There has been, it is believed, a small increase in the number of wells constructed for irrigation purposes, but nothing comparable to the increase since 1896-97 in the well tract. That the figures show a small decrease must be due to canal extensions such as the Mat and Fatehpur branches resulting in the displacement of well by canal irrigation, and also in some measure to the reduced supply in some of the wells in 1907-08 owing to the fall in the ground-water level. The figures for 1907-08 show an increase of 14·8 per cent. in canal irrigation and of 8·3 per cent. in the total area irrigated.

When the monsoon ends as prematurely as it did in 1896-97 and 1907-08, the lack of moisture in the soil necessitates irrigation for the preparation of the seed bed for the winter crops ; the valuable sugarcane crop too requires a watering at the same time. Hence the available supplies in the canals during the months of October and November, the season for the sowing of the *rabi* crops, determine the *rabi* area irrigated from the canals. The supplies during these two months were lower in 1907-08 than in 1896-97 and also throughout the *rabi* season : the average daily discharge at the heads of the canals "utilized" throughout the *rabi* was 9,986 *cusecs* in 1896-97 and 8,814 *cusecs* or 1,172 *cusecs* less in 1907-08.

The depths of water on the irrigated area based on the utilized discharges at the heads of the canals were as follows :—For the *kharif* 2·80 and 2·52 feet, for the *rabi* 2·17 and 1·79 feet, and for the whole year 2·41 and 2·11 feet respectively. The depth of 2·11 feet is equivalent to a depth of 0·45 foot over the gross area commanded by the canals, *viz.*, 14,704,000 acres.

The reduction in the *rabi* depth is to a certain extent a measure of the economy effected in the distribution of water, but it is not an absolute measure, as in such years two waterings at least in addition to the *paleo* are required for the proper maturing of the crop, and so many with a diminishing supply it is not possible to give to the whole area which has received a *paleo* watering. In 1907-08 for this reason partial or full remissions had to be granted on some 7 per cent. of the area *paleoed*, which figure was probably larger than that for 1896-97.

As far as I am aware, there has been no such serious fall of the ground-water level in this tract as to cause anxiety to the irrigators from wells, although the fall which is the natural result of a sequence of dry years has been well marked. The fall, moreover, has to some extent been lessened by the more continuous running of the canals on account of the drought, resulting in increased see page therefrom.

In the case of this tract, therefore, the main question does not appear to me to arise and the palliative measures proposed by Mr. Molony need not in consequence be considered.

The only tract within the area commanded by canals, and not a very large one, with which I am acquainted, in which there has undoubtedly been a considerable and permanent fall in the ground-water level, is that lying along the Karon Naddi in the Muttra District and may be referred to here as bearing on this question.

In order to relieve excessive flooding which occurred higher up this valley in the Aligarh District some time in the eighties, the channel of the Karon Naddi was rectified and improved. In my opinion the fall in the ground-water level which has since been observed is chiefly due to the quick removal of the water which previously accumulated in widespread depressions within the catchment area of this Naddi and, in some small degree also, to the deepening of the channel by erosion and not, as has been often suggested, to the abstraction of water from the Jumna, which runs at a distance of some 14 miles parallel to this tract, by the Jumna canals.

For the past 30 years or so the Irrigation Department has kept annual records of the rise and fall of the ground-water along various lines across the Jumna-Ganges Doab, roughly at right angles to the general slope of the country from west to east. These observations are made twice a year, in November when the level may be expected to be at its highest and in May when it may be expected to be at its lowest; they are made at suitable non-irrigation wells at intervals of two or three miles along these lines.

When the writer was Chief Engineer in the United Provinces the question of a Sarda Canal for Oudh again came to the front and similar observations were ordered to be made across the

Ganges-Sarda Doab and these, if the canal is made, should afford valuable information as to its effect on the ground-water level.

In the case of the Jumna-Ganges Doab the observations were unfortunately not instituted until some years after the construction of the canals as their importance was not then recognized. It is known, however, that the rise due to seepage from the canals, especially in their proximity, has been considerable.

The main object of these observations is to enable the Canal Engineer to watch the rise of the subsoil water level in order to be ready to adopt certain measures, such as surface drainage, restricted irrigation, etc., to counteract the combined effect of rainfall, irrigation, and seepage in unduly raising this level.

It was not realized until some time after the introduction of canal irrigation into these provinces that the water poured on to the land, in addition to the seepage from canal channels, not only tended to raise the ground-water level unduly, which led to water-logging in low-lying tracts, but also rendered the soil less capable of absorbing the natural rainfall, which led to serious flooding in wet seasons. During a series of wet years in the eighties the resultant evils became so serious and created such an outcry against the canals that extensive drainage measures were undertaken, consisting in the improvement of the natural drainage channels and the construction of many miles of surface drains. These measures have proved entirely satisfactory and but few complaints of water-logging or flooding being due to the canals are now heard of.

In confirmation of this I need but instance the deplorable condition of the Farrukhabad District in the eighties after a cycle of wet years as compared with its present condition since extensive drainage works were carried out by the Irrigation Department. It has been, however, conclusively proved by the late Mr. J. R. C. Nicolls (*vide* his Report on the Kali Naddi Drainage) that canal irrigation as compared with the excessive rainfall played but a minor part in the deterioration of that district.

It is suggested by Mr. Molony as a matter for serious consideration whether the policy of surface drainage has not been carried too far by the Irrigation Department.

In regard to the natural phenomena such as rainfall, floods, and climate it has been truly said that men's memories are very short. There is no proof whatever that the climate of India is changing, the law of averages must prevail, and the recent cycle of dry years will be followed, as surely as the night follows the day, by a cycle of wet years. The United Provinces are frequently subject to cyclonic storms with heavy rainfall towards the close of the monsoon, which occasion widespread flooding. I have a very clear recollection of such a storm in the first fortnight of October 1903 which, fn some three or four days, gave the extraordinarily heavy rainfall of 18 to 20 inches over the whole of the area commanded by the Lower Ganges Canal, some 10,500 sq. miles, and was the cause of serious and extensive flooding; nevertheless the drains constructed by the Irrigation Department afforded such relief that practically the whole of the area could be prepared for the *rabi*. Had this not been the case the ground in many parts would have become water-logged, the ground-water level unduly raised, and thousands of acres must have remained unsown. Clearly it is not the case here that the country has been over-drained, and, if a longer view be taken in anticipation of the inevitable return of a cycle of wet years such as has come within my experience, it will not be found that the country has been over-drained.

(*To be continued.*)

TABLE

Year	Rainfall	Total area	Normal cultivated area	Not available for cultivation	Canal irrigation	Well irrigation	Irrigation from other sources	Total *ek-fasli* irrigated area
	Ins.	Acres	Acres	Acres	Acres	Acres	Acres	Acres
						CANAL TRACT (nor		
1896-97 .	16 80	17,206,635	10,960,000	Forests 191,339; 3,082,362; Total 3,273,701	1,817,679	2,333,189	146,289	4,297,157
						2,479,478		
					843,269	11½% 285,139		
					2,660,918	2,764,617		
1907-08	17·26				2,310,802	2,328,188	233,389	4,892,379
						2,561,577		
					745,560	300,465		
					3,056,362	2,862,042		
Difference ...	+0 46				+395,414 +14·8%	+97,425 +3·5%		+ 595,222 + 13·9%
						WELL TRACT (nor		
1896-97 ...	22 40	12,832,748	7,523,000	Forests 392,166; 1,875,553; Total 2,267,719	15,595	1,361,215	439,891	1,816,701
						1,801,106		
					5,731	9¼% 171,105		
					21,326	1,972,211		
1907-08	20·86				16,715	2,034,068	354,868	2,405,651
						2,388,936		
					5,356	226,781		
					22,071	2,615,717		
Difference .	—1·54				+ 745	+ 643,506 + 32·6%		+588,950 +32·4%

I.

Total annual irrigated area	Total cropped area	*Do-fasli* area	Masonry Wells: In use	Masonry Wells: Available	Non-Masonry Wells: In use	Non-Masonry Wells: Available	Canal Irrigation: Kharif and Sugar	Canal Irrigation: Rabi
Acres	Acres	Acres	No.	No.	No.	No.	Acres	Acres
mal rainfall 30 14 ins.)								
5,425,565	11,627,343	2,139,896	?	112,725	?	316,828	1,047,819	1,614,187
5,918,404	11,699,788	1,901,559	133,616	164,244	306,898	357,601	1,325,402	1,724,960
+492,839 +8 3%	+72,445 +0·6%	−238,337 −11·1%	?	+51,519	?	+40,773	+277,583 +26·5%	+110,773 +6·8%
mal rainfall 38·60 ins.)								
1,993,537	8,162,058	1,594,096	?	68,072	?	272,396	11,841	9,485
2,637,788	8,446,250	1,138,903	168,978	117,279	561,079	572,283	10,409	11,662
+644,251 +32 3%	+284,192 +3·5%	−455,193 −28·5%	?	+49,207	?	+299,887	−1,432	+2,177

THE PRESENT POSITION AND FUTURE PROSPECTS OF THE NATURAL INDIGO INDUSTRY.

BY

W. A. DAVIS, B. Sc., A. C. G. I.,

Indigo Research Chemist to the Government of India.

(Continued from page 46, Vol. XIII, Pt. I.)

II. Present Methods of Manufacture in Bihar.

Although, since the war, the actual output of indigo from the Madras Presidency, the United Provinces, and the Punjab has considerably exceeded that of Bihar * the manufacturing methods in use in the former provinces are much inferior to those employed in Bihar. In Bihar the manufacture of indigo is in the hands of large concerns, often producing 500 to 1,000 maunds of cake indigo in the season, and equipped with steam-power and under European supervision. In the other provinces the industry is with a few exceptions carried out by small village operatives using comparatively primitive methods which give a relatively poor yield of dye and a low quality product. Before the war the manufacture of indigo had practically ceased in all parts of India except Bihar. The quality of natural indigo is an important factor in determining its use by the dyer, and the low grade indigo of Madras and the other provinces (often deliberately adulterated) was gradually excluded from the world's markets by the high quality synthetic indigo of the German manufacturers. In the present article the methods actually in use in Bihar will be described; it will then be practicable to consider the defects existing in these and the possibility of effecting improvements in both agriculture and manufacture.

---

* See Table VI, page 41, Vol. XIII, Pt. I of this *Journal*.

THE INDIGO PLANT.

Two species of indigo are cultivated in Bihar :—

(a) *Indigofera Sumatrana,* or Sumatrana plant.

(b) *Indigofera arrecta,* or Natal-Java plant, generally called now simply "Java plant."

The *Sumatrana plant* is still the principal form of indigo grown in the United Provinces, Madras, and the Punjab, and the seed of the Sumatrana plant grown in Bihar is obtained from the United Provinces. The plant is not grown at all for seed in Bihar, as the conditions appear to be less favourable than in the United Provinces.

The *Java plant* was introduced into Bihar by Mr. H. A. Bailey, who visited Java in 1899 on behalf of the Indigo Improvements Syndicate which was at the time carrying out experimental work under the direction of Bernard Coventry at Dalsing Sarai. In the two or three years following 1901, experimental work was carried out to ascertain the best methods of sowing and cultivating this plant in Bihar and of obtaining seed. About 1904 its cultivation was taken up generally in Bihar, and it was rapidly superseding the Sumatrana plant, when certain peculiar difficulties were encountered, with which I shall have to deal in detail later.

From the large number of trials made by Rawson (*Report to the Bihar Planters' Association*) during the years 1900-1902, the yield of 60 per cent. indigo from the Sumatrana plant varied from 6 to 12 seers per 100 maunds of average green plant. There is no doubt that the *quality of the soil* on which the plant is grown largely influences not merely the actual yield of green plant (a point to be considered later), but also its quality. Thus the trials made by Rawson showed that the Sumatrana plant grown on old *zerat* lands (lands held and cultivated by the factories) gave a considerably lower yield of indigo per 100 maunds of plant than on *zillah* lands (lands worked by ryots and not systematically stripped by growing one crop—indigo—continuously). Thus the average yield in Rawson's trials with *zillah* plant in two seasons was 11·6 seers per 100 maunds, whereas with *zerat* plant the average was only 5·1 seers, or less than half. This difference is all the more striking, bearing

in mind the fact that the *zerat* lands have generally greater advantages in the way of better cultivation by superior implements than the *zillah* lands cultivated by the ryots. At the present time, from returns sent in to me from different factories for the season 1916-17, the average yield of 60 per cent. indigo per 100 maunds of green Sumatrana plant may be taken as 8 to 9 seers.

The Java species not only yields, as a rule, far more green plant per acre than the Sumatrana indigo, but far more dye per 100 maunds of plant. The early experiments made by Francis Coventry at Dalsing Sarai in 1905 gave the following results *for the first cutting only* :—

Plant	Area grown Acres	Mds. cake indigo produced	Indigo per 100 maunds plant		Seers indigo per acre		Mds. green plant per acre
			s.	ch.	s.	ch.	
Sumatrana	2,130	326	8	12½	6	2	70
Java	571	171½	13	6	12	0	91

There is an increase with the Java plant of 30 per cent. in maunds of green plant per acre, of 50 per cent. on the yield of indigo per 100 maunds of plant, and of over 90 per cent. on the yield of cake indigo per acre.

Bergtheil in his *Reports of the Sirsiah Indigo Research Station* of 1906 and 1907 gives the following comparative results with the two kinds of plant ; in these seasons returns were made to him of the actual results obtained by the indigo factories of Bihar working both forms of plant on the large scale.

Year	Concern		Average yield cake indigo per acre		Average yield per 100 maunds plant	
			s.	ch.	s.	ch.
1906	Average of 20 indigo factories	Java	14	6	14	13
		Sumatrana	10	15	12	4
	Sirsiah	Java	——	——	17	0
1907	Average of 31 indigo factories	Java	20	9	15	0
	Sirsiah	,,	19	3	16	1

Thus the *average* from 20 factories in 1906 showed an increase with the Java plant of nearly 40 per cent. in the yield of cake indigo per acre, and an increase of about 20 per cent. in the yield per 100 maunds of plant. The average yield of indigo per acre is considerably higher than the yield per acre obtained by Francis Coventry at Dalsing Sarai; but it must be remembered that the Dalsing Sarai figures give only the results of a single cutting (*moorhan*) whilst the figures above refer to the whole season's make (*moorhan* and *khoonties*). The difference in the produce per 100 maunds of green plant is not so apparent in the average returns from the factories as at Dalsing Sarai, but the average factory value, 12·4, obtained for Sumatrana plant in 1906 is unusually high and the value for Java plant unusually low. The returns sent me by factories for the year 1916 showed the *average* yield for the whole season per 100 maunds for Sumatrana plant to be 8 to 9 seers, whilst for Java plant it was 16 to 18 seers. In most factories for which I have returns, the produce per 100 maunds was 50 to 100 per cent. higher than for Sumatrana, which bears out the results obtained at Dalsing Sarai in 1905.

Actual analyses have shown that whilst the Sumatrana plant at the time of *mahai* contains on the average from 0·4 to 0·6 per cent. of indigotin *in the leaf*, good Java plant contains nearly double this amount, *viz.*, from 0·8 to 1 per cent. of indigotin. The percentage of leaf on the total weight of the plant put into the vat is, too, generally somewhat higher with Java plant (about 50 per cent.) than with the Sumatrana plant (40 per cent.). As the actual yield of green plant per acre for good Java indigo is 30 per cent. higher than for Sumatrana and the plant is frequently twice as rich in indigotin, it can easily be understood that the yield of cake indigo *per acre*, which is the principal consideration for the planter, is frequently more than twice as great with the Java plant as with the old Sumatrana plant.

The great importance is therefore obvious of increasing the cultivation of the Java plant in place of the old Sumatrana in order to cheapen production and so enable natural indigo to compete with synthetic in price. Unfortunately, however, serious difficulties

have been encountered in the past few years in extending the cultivation of the Java plant. These difficulties and the means by which they can be overcome will be dealt with in detail later.

Cultivation and Sowing.

The Java indigo plant is usually sown in Bihar about the middle of October after the rains have ceased. The plant germinates in a short time, but during the cold weather there is little growth—by January it is only a few inches high—but when the warm weather comes it develops rapidly, and by May or June is ready for the first cutting—the *moorhan* crop—of leaf for manufacture. It is usually cut down at this time to about six inches from the ground, and is then left for another month or six weeks for a second crop of leaf. If the soil is a good one, the stumps send out vigorous shoots which grow rapidly and give a good leaf crop—the so-called *khoontie* crop or second cutting.

In districts which are subject to early flooding in July or in August, it has been found to be a great advantage to sow the Java crop as early as possible, *viz.*, in September instead of October, if the state of the land after the cessation of the rains makes cultivation possible. The plant is then ready for the first *mahai* much earlier, namely, by April or May, and a second cutting can be obtained in June or July before the floods come and destroy the *khoonties*. In this way some factories which habitually lost *khoonties* by early flooding have been able to secure an early second cutting.

The Sumatrana plant is usually sown about the middle of February, either after a fallow or after a *rabi* crop. If Sumatrana plant is sown in October or November it does not thrive, probably owing to its being unable to withstand cold weather, and a large proportion dies out.

Before sowing the fields have to be thoroughly prepared. The land is first hoed to remove weeds, and is then ploughed by means of bullock-drawn ploughs which first furrow lengthwise and then across at right angles. After ploughing the soil is broken up and smoothed by means of a *hanga*, which is a heavy wooden log drawn

by a pair of bullocks. The land is a few days later ploughed again, and the soil again broken up and smoothed by the *hanga*. These operations may be repeated three or four times. The surface soil is thus brought into a finely powdered, loose condition, which affords a good seed bed, whilst the compacting of the surface allows of the capillary rise of moisture and prevents rapid evaporation. The sowing is generally effected in lines by means of simple drills which distribute the seed at proper intervals. Generally with Java plant the sowing for a leaf crop is at the rate of 5 to 6 seers of seed per acre, but with Sumatrana seed a larger quantity is required, *viz.*, 8 to 12 seers per acre. The exact quantity of seed will be regulated by the germination of the seed, and with a seed germinating 100 per cent. a smaller quantity of seed will naturally be required than with a seed of lower germination.

Treatment of Java indigo seed before sowing. The Java indigo seed has an exceedingly thick seed-coat, and unless properly treated before sowing it germinates very slowly and incompletely. The seed may either be scarified in a scarifying machine immediately before sowing or treated with sulphuric acid, as was originally suggested by Dr. E. J. Butler of Pusa in 1906. When Java indigo was first introduced into Bihar, one of the obstacles to its rapid adoption was the difficulty of obtaining a satisfactory germination after sowing. This difficulty was entirely overcome by the methods suggested.

The best method of treating the Java indigo seed is as follows :-

A maund of seed is placed in a wooden tub and 3—5 seers of strongest sulphuric acid, specific gravity 1·84, is added and thoroughly mixed in with the seed, so that every seed is wetted. For the sake of economy the minimum quantity of sulphuric acid should be used, and if the stirring is carefully done, the seed can be properly wetted with 3—4 seers of the strong acid. The 20 minutes should be counted from the time of first adding the acid and includes the 5 minutes necessary for a thorough mixing. With some soft-shelled seed, somewhat less than 20 minutes gives the best results.

At the end of the treatment, 20—30 gallons of water are rapidly added and the seed quickly stirred whilst the water is being poured in. Then leave for about half a minute for the seed to settle and pour off the washing water. This washing should be repeated at least five or six times, so that every trace of acid is removed. Finally the seed is drained as dry as possible and spread out on sheets to dry, in the sun if possible, turning over the seed frequently so as to facilitate rapid drying.

Weeding. Prior to sowing, the lands have to be kept scrupulously "clean" by constant weeding. During the early growth of the indigo, weeding is also frequently necessary, and it is desirable to harrow the fields to break up the hard-baked top soil and conserve the moisture during the hot weather. The harrowing obviates too a good deal of weeding.

Cutting. The Java plant is ready for a first cutting earlier than the Sumatrana, generally towards the end of May or early in June. The Sumatrana plant is not usually ready till a month or six weeks later. The exact time of cutting any particular field is regulated by practical considerations. The low-lying crops are first cut, because, with a more abundant supply of moisture, they have grown more luxuriantly, and because delay in cutting may lead to loss by flooding, either of the first or second crop. On some estates a large proportion of *khoontie* crops is frequently lost from flooding. There is little doubt that there is a steady increase in the indican content of the indigo plant during June and July, so that the crop should be cut as late as possible consistent with practical necessities. The plant is not only larger and yields more leaf, but the leaf is actually richer in indigo and gives higher produce per 100 maunds of plant. But if the plant is left too long before cutting it may begin to shed leaf, and so the actual yield will be diminished—this is especially the case in rich soils where the growth has been rapid.

The Sumatrana plant is usually not cut until the middle of July.

Between the first and second cuttings there is an interval of six weeks to two months. The first *mahai* may last, including

cuttings from both Java and Sumatrana plant, from say June 1st till early in August. Then after an interval of about a month a second *mahai* will follow, covering 20 to 30 days in September.

One of the great advantages of the Java plant has been that not only does it yield a heavy first crop, rich in indigo, but it is ready for cutting very early (frequently in April or early May), as compared with Sumatrana. A second cutting can therefore frequently be obtained in fields subject to early flooding, in which the ordinary Sumatrana *khoonties* would be entirely lost. The Java indigo is also remarkably resistant to slight immersion in water during the rains. Provided the crop is not entirely submerged, or that the water does not stand for too long a period, the Java crops receive little injury from an amount of water-logging which would in a very short time entirely destroy a Sumatrana crop.

Special methods of cultivation. A good deal of indigo is grown on low-lying lands in Bihar and Bengal, near river banks, on soil which is annually inundated and has a fresh layer of silt deposited on it. In such lands the indigo is sown broadcast after the river has subsided in October. Such cultivation usually gives a very good crop, but, as a rule, only a single cutting can be obtained as the rise of the river entirely covers the land. In the United Provinces where the soils are less retentive of moisture, Sumatrana indigo is grown on irrigation or is sown late after the rains have begun, when it gives a late first cutting in September. No second cutting is taken.

MANUFACTURE.

Transport to factory. The plant is cut in the early morning and carried to the factory in carts drawn by two bullocks. It was formerly the custom in Bihar, and is frequently still so in the United Provinces, to cut the plant before daybreak. I have not been able to ascertain why the old custom in Bihar was abandoned. It is quite possible that the indigo plant may be richer in indican at night than in the day, and it certainly is an advantage to get the plant carried to the factory before the sun gets much power. There is no doubt that indigo which has to be brought from some distance

—frequently from six to eight miles—may undergo serious deterioration by exposure to the sun's heat. It then blackens or "burns" and the content of indigo in the leaf, as determined by analysis, shows a marked falling off. There is no doubt that prolonged exposure to the sun causes the liberation of the so-called *enzymes* in the leaf which act destructively on the indican—the parent principle of the indigo—so that it is clearly desirable to have the indigo cut as early as possible and brought to the factory in the early morning.

Loading the vats. Plate XV, fig. 1, shows the arrival of the bullock-carts charged with leaf at the vats. Fig. 2 in the same plate shows the loading of the leaf indigo into these. In Plate XVI, fig. 1, one of the vats has been filled with plant and the crossbars fastened down to prevent it from rising during the fermentation. Pieces of bamboo are placed across the vats below the crossbars for this purpose. These are shown in Plate XVI, fig. 2, resting on the edge of the vats.

Nature of the vats. The steeping vats are constructed of brick covered with Portland cement. Six or more vats form a range. The vats generally have a capacity of a little more than 1,000 cu. ft. with dimensions $18' \times 16' \times 3'$—$9''$ deep, the depth being measured to the cross beams. In some factories the vats are double-sized, that is with a capacity of 2,000 cu. ft.

Along the steeping vats, but at a slightly lower level, are the *beating vats*. (Plate XVI, fig. 2.) There is usually one large beating vat to six steeping vats. A wall 3 feet high runs down the centre of the beating vats, but a space is left at each end so as to ensure free circulation. The beating is now usually effected in Bihar by means of a wheel (wheel beating) driven by power. It is shown in the left hand upper corner of Plate XVI, fig. 2. This wheel has radial rods on which small flat paddles are fixed. As the wheel revolves the liquor is thrown up into the air as a fine spray, so that rapid oxidation can take place. The movement of the wheel causes a circulation of the liquor round and round the beating vat.

In many factories the beating vat has two partitions, and the wheel then works in the centre division.

Fig 1. ARRIVAL OF INDIGO AT THE VATS.

Fig. 2. LOADING THE VATS.

Loading the vats. Former experiments by Bergtheil showed that the best results appear to be obtained in the case of the *Java plant* with a comparatively light loading, *viz.*, 75 to 90 maunds of plant per 1,000 cubic feet of vat-space. The Java plant contains far more indican than the old Sumatrana form, and if heavier loading is adopted a considerable proportion of the indigo remains unextracted and the efficiency falls off. On the other hand with Sumatrana plant, to work with a heavier charge is found to be more economical. The vat is usually charged with 110 to 120 maunds of plant.

Temperature of water and time of steeping. The steeping is generally carried out at a temperature in the neighbourhood of 90°F. From Bergtheil's experiments a scale of times of steeping was worked out according to the temperature of the water. The following gives the values :—

Times of steeping.

Temperature (in degrees, F.) ..	...	90°	93°	96°	99°	102°	105°
Period for Java plant ..	hours	12½	11½	10½	9½	8½	7½
Period for Sumatrana plant ...	hours	10½	9¾	9	8¼	7½	6¾

This works out to a decrease of 20 minutes steeping for every degree rise of temperature in the case of Java plant, and of 15 minutes in the case of Sumatrana plant. The temperatures given are the *averages* during the steeping period, that is, the mean between the temperature at the time of filling and that when the water is run off.

Plant cut before the break of the rains is generally richer in indican than the fresh growth following the rains. With such plant two hours extra steeping should be given at 90° F.

A temperature below 90°F. is considered unfavourable to a proper fermentation and should be avoided. Many of the Bihar factories are fitted with a steam pipe which runs along the *murree* or channel conveying water from the reservoir (*khajana*) to the steeping vats. This is shown in the foreground of Plate XVI, fig. 2. The steam is blown out from a number of perforations in the pipe

into the water as it flows along, and so raises its temperature to the necessary point. The temperature is measured by a thermometer as the water enters the steeping vat, and is maintained as nearly as possible at 90°F., which is generally adopted now as the standard temperature for steeping.

Changes in steeping. During the 10 to 12 hours period of steeping a fermentation occurs in the vats. This usually begins three or four hours after the plant is covered with water and is accompanied by a brisk evolution of gas--mainly nitrogen in the early stages, although later on considerable quantities of hydrogen and carbon dioxide are produced. This is not the place to discuss in full the mechanism of the changes occurring, but, briefly, the result is the transformation of the *indican*, the form in which the indigo occurs in the leaf, into indoxyl, which is dissolved in the steeping water and imparts to it the greenish fluorescence characteristic of the liquor when it is run out into the beating vat. The steeped plant—called *seet*—is removed from the vats and is used as a manure for the fields. Owing to its high content of nitrogen it is a very valuable manure for cereal and non-leguminous crops.

Beating. When the steeping is complete, the liquor is run off from the vats into the beaters. Six steeping vats are usually emptied as nearly as possible at the same time, and the whole lot of liquor beaten together. It is important *to ensure a good yield and a good quality of indigo that the liquor should be beaten immediately after it is run off* and not allowed to stand for even an hour. If left, a rapid series of decompositions occurs and the indoxyl is transformed into valueless substances other than indigo, which are carried down with the indigo during beating and give rise to a product of low purity (low indigotin content).

The beating is in practically all factories of Bihar effected by the *beating wheel* described above. It generally occupies about 1½ hours, but in favourable circumstances may be complete in an hour. In some cases a longer time is necessary— two or three hours —but in general, when prolonged beating is necessary, the product is of a lower grade of purity, and loss of indigo occurs probably owing to bacterial and chemical decomposition of the indoxyl.

Fig. 1. THE VAT LOADED WITH PLANT AND FILLED WITH WATER.

Fig. 2. THE BEATING VATS

The progress of the beating should always be carefully controlled by removing samples of the liquor from the vat and after allowing the precipitated indigo to settle, testing a little of the clear liquor by exposing a piece of absorbent paper (white blotting paper or filter paper), moistened with the liquor, to the fumes of ammonia gas. For this purpose the paper is held over the mouth of a bottle of ammonia. If the beating is incomplete, the blotting paper, where the ammonia comes in contact with it, becomes slightly blue or greenish in colour. The beating should be stopped *immediately* the test indicates that the whole of the indoxyl has been oxidized.

During the beating the soluble indoxyl is oxidized by the air to the blue pigment indigo. A layer of froth forms on the surface of the vat, sometimes two or more feet high. This froth has to be broken up by coolies who walk round and round the vats with a cloth stretched out between them. This is shown in Plate XVI, fig. 2. When nearing completion, the froth which is at first blue becomes more and more white and gradually disappears.

Settling the indigo. After beating the indigo " fecula " is allowed to subside. This usually takes two or three hours. A good subsidence is an indication of favourable working, and the more rapid as a rule the subsidence the better is the yield of indigo and the higher its purity. In rainy weather, the settling often takes place slowly and the indigo fails to subside in the form of a heavy fecula. In such cases the " seet water " which is run off contains finely divided indigo in suspension and is tinged green. When planters have a " green vat," subsequent operations become difficult and considerable losses of indigo occur.

After beating, the supernatant liquor—the " seet water "—is run off. In most factories, the vats are furnished with cut-off pipes, which revolve and can be adjusted to different levels. In others the running off is effected by opening a series of wooden plugs arranged down the side of the vat. The beating vat slopes down to one corner where the precipitated indigo or *mal* is collected. It is then passed through one or two strainers, and flows to a well or " mal jhari " from which it is raised by a pump or steam injector

to a large rectangular tank. The *mal* is again strained once or twice to remove sticks, dirt, and straw, on its way from the well to the boiling tank.

Boiling. The liquid containing the indigo (to the extent of about 0·5 per cent.) has to be heated to prevent fermentation which would cause loss of indigo, and to facilitate good filtration. The best practice is to boil it with very dilute sulphuric acid, which greatly improves the quality of the indigo by removing impurities, (*e.g.*, mineral phosphates, and the "indigo gluten" which is soluble in dilute acid). The best method of doing this is as follows :—The *mal* is heated to about 160°F., immediately after lifting, in large rectangular iron tanks, by blowing steam directly through the *mal*. The *mal* is then allowed to settle, and the clear liquid above the sediment gradually run off by removing pegs, one after the other, from holes perforated in regular order in the side of the iron tank.

After the first heating, as large a volume of fresh water is added as is conveniently possible. Steam is now turned on and the necessary quantity of sulphuric acid added. In general about 4 to 6 lb. of strong sulphuric acid should be used for the *mal*, corresponding with 1,000 cubic feet of steeping-vat space. The acid is diluted with about 10 times its volume of water in a tub placed above the boiler and fitted with a long handled plug. Care must of course be taken in diluting the acid to add the acid to the water and not *vice versa*. After adding the acid, the temperature is again raised by steam, *this time to about* 160°*F*., the indigo again allowed to settle, and the water again cut off. Finally, water is added and the temperature raised nearly to the boiling point (200° to 210°F.), the *mal* is again settled, and the clear liquor cut off, when the *mal* is ready to run off to the filtering "tables."

The heating to 160°F. with acid instead of boiling directly has been found in practice to give the best results. If the *mal* is heated to 212°F. with acid straight off, troublesome frothing occurs and the grain of the indigo is broken up, so that a very finely divided and badly settling indigo is obtained, which also filters very slowly.

The above process of purification will convert an indigo testing 60 per cent. indigotin into one which contains 65 to 70 per cent.

Fig. 1 FILTERING AND PRESSING INDIGO

Fig. 2. FILTER AND PRESS HOUSE.

of indigotin on the dry substance. With low grades of indigo (50 to 60 per cent.), a larger quantity of sulphuric acid is necessary than with higher qualities (60 to 65 per cent.), in order to remove the impurities.

Filtering the indigo. After boiling, the *mal* is run on to the filtering tables shown in Plate XVII, fig. 1. Usually these are about 18 feet long by 7 feet wide. They are made of light battens fixed on a stout wooden frame with sides about 18 inches high and sloping as shown in the photograph. Across the table is stretched the stout cotton cloth specially made for the purpose, which is used to retain the indigo. The table stands in a shallow trough of cement, which is surrounded by a drain to carry off the filtrate. When the thin *mal* is first put on the cloth, the filtrate runs through blue, and such runnings are pumped back on to the cloth and refiltered. Finally, the filtrate becomes perfectly clear. If the early operations have been favourable, the clear liquor is of a light sherry colour. Much of the liquid is allowed to filter through the cloth, but to save time a large proportion is removed, as settling proceeds, by gradually lowering the cloth at one corner, so as to "cut off" the rest. The paste is then scraped down to one end of the frame and the cloth folded over to squeeze out as much liquor as possible. After draining in this way the pulpy mass (thick *mal*, containing from 8 to 10 per cent. of indigotin) is carried to the presses in wooden boxes.

Pressing. The presses are shown in Plate XVII, fig. 1. Each consists of a rectangular box, the framework having on all sides numerous perforations. The box is fitted with two thicknesses of strong, closely woven cloth into which the thick *mal* is packed. Pressure is applied by means of screws, working on to heavy cross beams. The screws are turned by means of heavy nuts rotated by long levers; six or more coolies operate this as shown in the photograph.

The boxes are usually built in two sections, each 6 inches deep. They are filled with the paste until the indigo has a depth of 12″ to 13″ at the beginning of pressing. When filled, a perforated wooden cover is put on and pressure *gradually* applied so as to

squeeze out water. The pressing takes several hours and is complete when the indigo has been pressed into a slab about 3" to 3½" thick. After pressing the moist cake is cut into smaller cakes of about 3" side, and each cake is stamped with the factory mark and the number of the day's boiling. They are then taken to the drying house. Plate XVII, fig. 2 shows the exterior of a presshouse of a small factory.

Drying. The drying-house is a lofty building containing a number of *machans* or frames fitted with shelves of light bamboos or wire netting. On these shelves the cakes are left to dry for several months before they are ready for the market. The drying is usually a slow operation, because the manufacture of indigo is largely carried out in the rains when the air is exceedingly humid. During the drying considerable bacterial fermentation occurs and ammonia gas is evolved. Mould grows abundantly and frequently forms a hairy mass, ½" to 1" in thickness, on the surface of the cakes. Although decomposition occurs in the indigo cakes during drying, there is considerable evidence to show, as pointed out originally by Rawson, that it is only the impurities of the indigo which are destroyed and not the indigotin, so that there is no loss of really valuable material. On the other hand a slight purification actually takes place owing to the destruction of the impurities, and the cakes actually become richer in indigotin. From time to time during drying the cakes are brushed, and when quite dry (in November or December) are packed into chests of well seasoned mango wood, each chest containing about 4 maunds of indigo.

Rapid working essential. In order to prevent unfavourable changes from occurring during the earlier stages, every effort is made to carry these through as rapidly as possible. The plant is brought to the factory with the minimum of delay, the loading is expedited by utilizing a full staff of coolies, and arrangements made to start the steeping of a whole range at nearly the same time. This is a point of great importance. If the vats are loaded at different times the steeping in the different vats will be finished at different hours. The liquor from the early vats would then have to be run out and wait in the beating vat to be beaten until the later vats

were ready. During such waits, decomposition occurs and undesirable organisms probably multiply, which have an injurious effect on the liquor subsequently to be beaten. Some of the most successful planters have informed me that starting the steeping in a whole range simultaneously, so as to run off the whole lot of liquor at once, makes a very great difference in the quality of the indigo and ease of working.

The vats are usually fully loaded and the steeping started by about noon. The steeping is therefore completed by midnight, when beating is immediately proceeded with, this operation in most cases being carried out at night. After settling, the liquor is ready to run off by daybreak, when the rest of the operations are carried through as speedily as possible.

Having described the existing methods of manufacture of indigo in Bihar, it is possible to consider how far they fall short of perfection and how they can be improved.

[I must express my indebtedness to Mr. W. Finch of Dholi Factory for kindly making arrangements for obtaining the photographs of Birauli out-works printed with this article. At this outwork the beating was carried out in the daytime instead of at midnight as is usually the custom now in Bihar, so that it was possible to obtain a photograph of this operation.]

(*To be continued.*)

THE CONSOLIDATION OF AGRICULTURAL HOLDINGS IN THE UNITED PROVINCES.

BY

PROF. H. STANLEY JEVONS, M.A., F.S.S.,

University Professor of Economics, Allahabad.

I. THEORETICAL INTRODUCTION.

IN a paper on the Capitalistic Development of Agriculture which I prepared for the meeting of the Industrial Conference at Bombay in December 1915, will be found set forth the theoretical considerations which prove unquestionably that the road for India's material advancement is through the increase of the productivity of agriculture. The present paper is an attempt to outline, so far as relates to the United Provinces, one of the most important practical steps which are necessary in order to realize a capitalistic development of agriculture. Needless to say, the investigations of numerous agricultural experts extending over many years have given us a vast and most valuable body of knowledge as to soils, crops, manures, and methods of cultivation. The difficulty now is not so much to make further scientific and technical discoveries as to make use of those we have. The huge agricultural population seems to be obsessed by a most obstinate inertia, so that the numerous efforts converging on it from without have no appreciable result. Agricultural instruction is offered, co-operation is fostered, selected seed is distributed ; but very many thousands who know of these offers of aid will not, or cannot, avail themselves of them. There would appear to be a moral apathy ; an appalling absence of ambition ; a fatalistic acceptance by the cultivator of his present limited means of subsistence and low standard of living.

My own observations do not altogether support this view. Speaking of the younger generation of ryots whose habits of thought are not entirely fixed, I believe the cultivator is as keen to improve his position, and to adopt any means within his reach which he believes will attain that end, as anyone in India. Ambition is soon crushed out of him, however, by the appalling dead-weight of physical, legal, and social conditions which he cannot change. His local obligations are extraordinarily onerous. There are stringent family obligations, besides those directly connected with his occupation. He is not a free man, as we understand personal freedom in England. In recent decades he has been further hampered by the growth of population, causing competition for land, so that rents have risen considerably in zemindari tracts, and the cultivator there has got little advantage from the rise of prices of agricultural produce.

It is an economic law of the very first importance that the earnings of any class, whether wage-earners or independent workers, like the cultivators, tend to conform to their standard of living which it is usually, though not always, more difficult to change, either upwards or downwards, than the average money income of the class. The standard of living is raised chiefly by two agencies : education and travel. A rise of the standard of living without the expansion of the means of gratifying it produces discontent almost as severe as a sudden fall of real earnings (*i.e.*, income relatively to retail prices). When the standard of living remains unchanged an increase of earnings without a corresponding increase of the standard of living simply reduces the amount of work done by the people in question. They become lazy and apathetic, and lose those sturdy and manly qualities which are produced by a wrestle with Nature which is hard but not hopeless.

In undertaking any great reform in agriculture, it has, therefore, to be borne in mind that the tendency will be for the beneficial possibilities in increased income to be whittled away—(1) in ryotwari tracts and the Punjab colonies by a growth of apathy and idleness ; (2) in zemindari tracts by increase of rentals (only slightly retarded where occupancy rights prevail) ; (3) in tracts of both

tenures by an increase of population and diminution of size of holdings.

In the absence of any great catastrophe such as famine, plague, or war, the standard of living alters slowly. It appears also to be true that the more educated a population is and the higher its present standard of living, the faster will a further rise take place and the greater will be the resistance to a fall of the standard of living. In England a new standard of living becomes fixed after persisting for only three or four years. In India probably prosperity must continue longer for the habits of life to become changed and adapt themselves to a higher scale of living and for this in its turn to become a habit.

It is not to be supposed, however, that the standard of living is, so to speak, the independent variable, to which the rate of earnings will sooner or later conform. There is here, as in almost every economic quantity, a case of action and reaction. The resultant is an equilibrium between the opposing forces, which forces are, however, themselves continually in a state of flux, more or less. The rate of earnings in any employment at any moment may be regarded as the resultant of an equilibrium between the standard of living and the marginal productivity of labour, the latter determining the demand for labour in that employment, the former determining the supply. The problem before us, therefore, is to increase the marginal productivity of labour in agriculture and at the same time to raise the standard of living of the cultivating classes, including labourers, so that they will feel it worth their while to supply additional labour by working a larger percentage of their time or with greater energy.

Once a higher standard of living has been established, the economic forces of degeneration, such as growth of population, which tend to rob the cultivator of the net produce of his additional exertion, encounter a very strong force of opposition. Persons having a high standard of living will go out of the cultivating business rather than suffer a considerable diminution of their standard of living; and they can do this by migrating to the towns where industries are springing up.

Whilst the standard of living and the marginal productivity of labour are at any moment in a state of equilibrium with one another, or are tending towards it, we must note that any change in the one has an effect in the future on the other. For example, a lower marginal productivity of labour will mean lower earnings and the possibility of maintaining only a lower standard of living. Result : the workers, after some unrest, gradually become accustomed to this low standard of living, and it tends to become fixed. Again, any higher standard of living means increased efficiency, for work is done more intelligently and for longer hours. This enables a more advanced organization of production to be undertaken ; this raises the marginal productivity of labour, which in its turn provides increased earnings, and a margin permitting the standard of living to rise still further.

There is thus a reciprocal effect of the rate of earnings and standard of living upon one another. This effect is often slow in acting, the necessary adjustments taking place in a few years—3, 5, 10, or 15 according to circumstances. On the side of the demand for labour the marginal productivity is determined at any time by the actual physical conditions of the instruments of production and by the state of business organization and the demand for the commodity produced, the latter, in the case of staple commodities, being measured by their prices in the large markets. In the manufacturing industries the instruments of production are constantly changing through the invention of new machinery, the building of new factories, and so forth. In agriculture, however, there is a peculiar fixity of the instruments of production apparently due to the special part played by land and the natural agents in all agricultural production and to its immobility. It is a peculiar and most important sociological fact that the laws and customs regulating ownership and use of land have a stronger tendency to persist than any other characteristic of society. The sentimental attachment of the people to the land, the importance of land as family property in all countries until the industrial revolution has been passed through, together with the inertia arising from long-formed habits, all contribute to making both the physical and legal conditions of

land tenure extremely persistent and difficult to alter by any extraneous action other than the *force majeure* of the law.

It is important for us to note that the physical condition of the land as regards not only its fertility, but its division into fields, as well as the legal conditions of tenure, have a decisive influence on the marginal productivity of labour in agriculture, and consequently indirectly upon the standard of living. The only change in physical condition which, in the present constitution of Indian society, is not resisted, is the subdivision of the agricultural holdings in ownership which arises from the prevailing laws of inheritance, both Hindu and Mahomedan. It would appear that this subdivision of holdings has been a sufficiently slow and gradual process in certain districts to allow the resulting decrease of the marginal productivity of labour to bring down the standard of living with it, perhaps almost to the same extent. I cannot cite any definite proof of the decline of the standard of living, but am inclined to think that it has taken place in certain districts where security of life and property was well established whilst the population was still sparse. Certainly there is a danger of the fairly high standard of living which is being created in some parts of the Punjab canal colonies slowly degenerating unless the two agents for raising the standard of living —education and travel—are vigorously applied.

From the foregoing considerations a conclusion of the highest importance follows. The inertia of the land tenure and customs causes the standard of living to become fixed at a level corresponding with the physical condition of the land. The consolidation of scattered holdings by re-stripping will create a new physical condition, and allow greater efficiency of agricultural methods, and thus a higher marginal productivity of labour and a higher standard of living. The mere rearrangement of fields into compact holdings will not, however, affect the average size of the holdings ; and it will not, of itself, do much to prevent the continuance of the process which is mainly responsible for the present condition of holdings. These will continue to degenerate by further subdivisions, although remaining homogeneous at first ; and the degeneration will be so slow that it will carry the standard of living down with it.

It would appear extremely unlikely that any external regulation can prevent the growth of population producing a further subdivision of the unit of cultivation which is the important aspect of the question. Further subdivision of ownership might be prevented by refusing perfect partition so as to produce any field or group of contiguous fields less than six acres in area. Enforcement of any law of primogeniture would be impossible; but a system of officially recognized trustees of estates imperfectly parted might possibly be devised.

This, however, would not really affect the question of the size of the unit of cultivation which is all-important from the point of view of improved agriculture; and so long as the ryot is content to cultivate a holding of less than 10 acres in area as his principal or only source of livelihood, so long will he do it in spite of any laws to the contrary, and lettings to tenants, occupancy and non-occupancy, will be made on that basis.

The only remedy for the evil tendency to a reduction of the average size of the unit of cultivation is by raising the standard of living so that people will refuse to cultivate small holdings and will seek occupations elsewhere rather than do so. This postulates the existence of openings in occupations elsewhere and these are undoubtedly arising in industries, and could be made available by the opening of waste lands for settlement in the Central Provinces, Assam, Punjab, and certain Native States. If the importance of such emigration were realized it could be properly organized. But unless migration is assisted and so comes to be regarded as a lesser evil than the lowering of the standard of living, we shall have renewed reduction of the size of the holdings cultivated.

I have already stated that the higher the standard of living becomes raised amongst a population the more tenaciously do the people cling to it. If the standard of living be raised but a little it may easily deteriorate; if it be raised to a considerably higher level there will be a far more than proportionate increase of the resistance to the economic forces tending to lower the standard of living.

The conclusion which I think is justified from the foregoing considerations is that the only way to effect a permanent increase of the standard of living is to raise it at one stroke—that is to say within a very few years—by reorganization of holdings so as not only to consolidate them but also greatly to increase the average size. It would be necessary, of course, that all remedial measures should be put into operation at once—the re-stripping of holdings; re-grouping so as to produce a larger average holding, with the concomitant removal of the surplus population; accompanied by definite demonstrations of improved agricultural methods on the reorganized village holdings, and the compulsory education of all children with a view to raising the standard of living. Improved communications designed to bring a metalled road to every *abadi* would be a necessary part of this reorganization of rural life. I wish to record my opinion that it is almost useless to undertake these measures piecemeal. The forces of degeneration are so strong with the existence of a low standard of living that each measure of reform would be successively defeated. Far better results would be obtained by making a combination of agricultural and educational reforms in one district at a time, maintaining the special measures of education for a sufficiently long period of time for a new and considerably higher standard of living to become fixed as a habit amongst a population.

Such a plan as I have outlined postulates a very considerable expenditure of public money in any district which should thus be put under a reorganization. There cannot be any question, however, in my own mind that this expenditure will be amply justified and repaid by the results that will be obtained. With larger holdings cultivated by machinery co-operatively owned, the produce per acre would be increased by 50 to 100 per cent. in different lands. The net social income after providing for the subsistence of the agricultural population at the higher standard of living supposed, would be sufficient to support a very much higher taxation. The question of the manner of collecting additional revenue is of no importance. It could certainly be collected because there would be so much more income from which it could be paid.

The district would, therefore, be more than self-supporting after the first few years, and could not only pay the interest upon any loan that might have been contracted for making roads or other works, but could also contribute proportionately a greater share than formerly to the general revenue of the province, thus making equitable repayment of the special expenditure which had been lavished on it in the early years of the reorganization. For a fuller discussion of the growth of social income from public works I would refer the reader to an article on The Art of Economic Development recently published by me in the *Indian Journal of Economics.**

So far as I am aware the relevant economic principles have been sufficiently considered in the foregoing introduction. I have stated them in terms of the zemindari system of land tenure ; but the statement would differ in no essential feature when applied to ryotwari tenure, for the State may here be regarded as the landlord, but one of a benevolent disposition, in most places refraining from taking a full economic rent. The reorganization will be more beneficial in the ryotwari than in the zemindari districts provided the standard of living is sufficiently raised ; but its benefits will be more transitory if the standard of living is not sufficiently raised because the larger margin of profit to the cultivator will merely enable population to increase faster and the subdivision of holdings to proceed so much the faster.

The principles which I have stated are in fact independent of law, being based upon the primary economic instincts of mankind. I do not think it necessary to discuss the legal aspect of such a reorganization because it appears to me that this is one of those fundamental reforms in which all existing law must be swept aside, the resettlement being based upon common principles of expediency and justice. Although it may be held that there are certain family rights of property in land, the loss of which can never be compensated fully by any money payment which would be within the financial possibilities of any scheme of reorganization, yet I am convinced that the State must adopt the policy that rights which cannot be

* Vol. II, Part 1, p. 52.

more satisfactorily adjusted by other means, as by the allotment of land in the reorganized village, or in some distant locality, must be compromised by a money payment. In the reorganization all rights whatever must first be liquefied and then a re-allotment of existing land should be made upon the basis most expedient for the community as a whole after the type of the new community to be created has been decided. The remaining rights would then be dealt with serially in such manner as to give the most benefit, or do the least harm, to the persons concerned. It would be dangerous to attempt to regulate any such reorganization by precedent, or to make it conform with the existing laws which have totally divergent aims, being mainly concerned with the maintenance of the *status quo*. Such a fundamental change can only be carried through successfully by reliance upon first principles, having constantly in view the welfare of the new community to be created and applying the broad principles of humanity to the cases of hardship which may be expected to present themselves.

(*To be continued.*)

THE TENTH MEETING OF THE BOARD OF AGRICULTURE IN INDIA.

THE tenth meeting of the Board of Agriculture was held at Poona from 10th to 15th December, 1917, under the presidency of Mr. James Mackenna, Agricultural Adviser to the Government of India. The meeting was a notable one from many points of view. This was the first occasion on which the Board enjoyed the honour of being presided over on its opening day by the Governnor of a Presidency, a Governor who in spite of his other onerous duties is still a practical farmer and was an agriculturalist before he was a Governor. It is to be hoped that in future when meetings are held in alternate years at centres other than Pusa, His Excellency Lord Willingdon's example will be followed not merely from a sense of duty or recognition of the growing importance of the Board but from a genuine interest in agriculture such as His Excellency displays. The subjects on the agenda were wide enough to appeal to not only the agricultural, but also the economic and industrial, interests. The number of those who took part in the discussion was the largest on record. The members (48 in number) were as usual drawn from the various Agricultural and Veterinary Departments. The visitors included, besides the Hon'ble Sir Claude Hill and the Hon'ble Mr. R. A. Mant, the Inspector-General of Irrigation, the Officiating Director of Army Veterinary Services, a University Professor of Economics, an Assistant Director of Public Instruction, a Registrar of Co-operative Societies, representatives of the cotton trade of Bombay and of firms interested in agricultural machinery and fertilizers. But the most noteworthy feature was that several non-official members of the Provincial Legislative Council were invited as visitors and they took an active part in the discussion and materially widened the lines of the debate.

As mentioned above, the first day's proceedings opened with a speech by His Excellency Lord Willingdon, which was characterized by an insight into the practical side of agriculture which was much to the point. His Excellency, after paying a tribute to the worth and work of the Agricultural Service, referred to his own personal experience in this country as a breeder of pedigree stock, so well known to the readers of this *Journal*, and invited those who were interested in dairying to inspect his herd and milk records at Ganeshkhind. Not a few availed themselves of the excellent opportunity so kindly offered by His Excellency of witnessing a practical demonstration of the results of scientific breeding and scientific feeding. In conclusion, His Excellency acknowledged in fitting terms the zeal and energy with which the Bombay Department of Agriculture has created a desire among the farming classes for improvement and progress.

Sir Claude Hill, Member in charge of the Revenue and Agriculture Department, Government of India, next addressing the meeting, echoed the sentiments of all present when he warmly thanked His Excellency Lord Willingdon for having honoured the Board by his presence on that day. He referred to the death of Professor Barnes in suitable terms and the loss occasioned to the Department by his premature decease. Sir Claude then dealt in detail with the various subjects set down for discussion by the Board and pointed out how the Agricultural Department could co-operate with the Military in the establishment of horse-breeding farms in different districts in India.

Time and space do not allow of full justice being done to the seventeen subjects discussed and the fifteen resolutions passed by the Board. For this the reader is referred to the published proceedings of the Board.* All that can be done here is to touch on a few salient points in the discussions that took place onthe various subjects.

The first item on the agenda evoked considerable interest both on the part of officials and the large number of non-officials who were present, as it dealt with the disability of agriculture over a

---

* *Proceedings of the Tenth Meeting of the Board of Agriculture in India*, 1917. (Supdt. Govt. Printing, India, Calcutta.)

large part of India arising from the fact that the size and distribution of the land holdings are such as to render them essentially uneconomic units. Here the Board was dealing with a problem of the widest interest to India and the subsequent debate dealt with all sides of the question from legal to agricultural. The Hon'ble Mr. Keatinge who opened the discussion showed in an interesting speech how this sub-division of land smothers any attempt at agricultural improvement almost at its birth. The root cause of this trouble lies in the existing law of inheritance, both Hindu and Mahomedan, which provides for the partition of a holding, however small, amongst the members of the family, and for the repartition of the sub-divisions so created at each generation and so on *ad infinitum*. The Hon'ble Mr. Keatinge was therefore in favour of starting with a permissive Act allowing any man to declare a holding indivisible for ever in spite of the existing law of inheritance, and then such a holding should descend by primogeniture. This, being the policy of least resistance beloved of all governments, brought forward some pointed suggestions from Indian members for more drastic action. The Hon'ble Dewan Bahadur Godbole who had once raised this question in the local Legislative Council was for compulsory consolidation of all holdings and then legislative prohibition of any re-division. Professor Stanley Jevons who spoke from the point of view of the economist advocated prevention of reduction of the average size of the unit of cultivation by raising the standard of living and reorganization of holdings so as not only to consolidate them but also to make them larger. He was for action on the lines as drastic as the "enclosure" movement of England, but with the consent of the majority of the owners of the holdings. Referring to the United Provinces which is not a ryotwari tract like Bombay but a zemindari province, the Hon'ble Mr. Hailey said that a change in the revenue law rather than in the law of succession would meet the needs of his province. The Director of Agriculture, Madras, relied more upon the awakening among the people themselves than on any legislation. He feared Mr. Keatinge's permissive legislation would have little effect unless accompanied by a campaign of enlightenment. Several other gentlemen took part in the

discussion and there was unanimity on the point that this crying evil should be put down. Sir Claude Hill who summed up the discussion believed that no good would come from riding roughshod over the traditional sentiments of a people not radically progressive, and the first step should be to give them an opportunity of showing how far they were prepared to take remedial measures on a permissive basis. That seemed to him the true merit of the compromise embodied in Mr. Keatinge's bill. If the benefits expected from the permissive measures were found to be illusory, it would be for consideration whether more drastic legislation on the lines proposed by the Hon'ble Mr. Godbole should not be resorted to. The resolution adopted by the Board on the motion of Dr. Mann recommended that the question be closely investigated and experiments made in each provincial area in consultation with the Registrar of Co-operative Societies with a view to the adoption of such measures as seem best adapted to meet the special local requirements and the introduction of such legislation as may be necessary.

Subjects II & III referred to the programmes of the Imperial Department of Agriculture and the Bacteriological Laboratory at Muktesar and of the Provincial and Native States' Agricultural and Veterinary Departments, and the absence of any debate showed conclusively that the Board was neither critical nor anxious for enlightenment on the subject of programmes. No criticisms or suggestions were forthcoming and the question arose as to the necessity of submitting these programmes to the Board. The view of the majority seemed that the programmes were in a way useful, but it was not necessary to submit them to the Board. It was therefore recommended that they should only be published annually as a separate compilation for circulation to all concerned.

The next two subjects (*IV & V*) dealt with the publications of the Department. It is pretty generally recognized that the Indian Agricultural Department has not got the full credit in the past for all the work it has done, partly because of the inadequate methods of publication then in vogue, but mostly because of the apathy with which agricultural problems are regarded by the public press in this country and the peculiar views taken in the few critical

articles which have appeared from time to time. Recently attempts have been made to popularize the departmental publications and make them more attractive, and the discussion on the subject elicited the fact that the *Agricultural Journal of India* was at least regarded as being of popular interest in its new form. With regard to the question of summarizing and indexing agricultural publications, the necessity for such work was widely recognized, but it was felt that there was no staff to undertake it. The Board recommended that the reports of agricultural stations in India should be summarized and indexed by the Imperial Staff at Pusa which will be strengthened for the purpose.

The question of holding sectional meetings of the Board of Agriculture in years in which a meeting of the full Board is not held (*Subject VI*) was then discussed and the Board recommended that meetings of the mycological, entomological, and chemical sections should be held in years in which there is no meeting of the Board, that these should not be confined to members of the Agricultural Departments but others interested in these subjects be invited to attend, that agricultural officers engaged in experimental work should also hold periodical sectional meetings to discuss their results and methods, and that the veterinary section should meet every three years. As regards the botanical section the Board did not think any sectional meeting necessary, for most of the officers are engaged in investigations on special crops or groups of crops, and it was felt that there would be little advantage in a botanist engaged in work on cotton and wheat meeting others working on rice and jute. The Board, however, expressed an opinion that members of the Department might with advantage arrange to see the work carried on by others engaged in the same branch of work in other provinces.

The problem how to deal with the short-sighted and evil practice of mixing and adulteration which is slowly bringing Indian produce into disrepute in foreign markets and robs the cultivator of the full share of his profits, has come more prominently to notice as the result of the war. As has been stated by the Government of India in a reference which has been made to all Chambers of Commerce,

it seems reasonable to suppose that the present war will be followed by a period of keen competition among industrial nations for materials of all descriptions and for products which India should be in a specially favourable position to supply, and when it is realized that the watering of cotton, the adulteration of jute, and the general monkeying of all other agricultural produce put forward for export in India has reached a fine art it seems hardly probable that an era of high prices or a reputation for commercial morality will automatically follow. No formal resolution was passed by the Board on this subject (*Subject VII*), but the report of the committee was adopted. The committee regarded the co-operative machinery as too slow for the changed conditions created by the war, and also brushed aside the proposed remedy of issue of certificates of purity either by Government or commercial bodies as cumbrous and expensive. In their view the most hopeful method would be that of control at the port of export and the refusal to allow the export of produce below a minimum standard of cleanliness or of purity, such a standard to be fixed by or in consultation with representatives of the trade both in this country and the countries to which the bulk of the produce is exported. Such a standard would of course vary with every class of commodities and for the same class would change from time to time. The committee also suggested that in order to defray the costs of examination at the ports an export duty should be levied. Once it is widely realized that traffic in adulterated produce is no longer a paying proposition, the trade will adjust itself to the requirements of the consumer.

So long as the bullock remains the chief motive power of the plough, the Veterinary Department and the Agricultural Department must follow each other about India and the development of veterinary science in India is therefore closely bound up with the progress of agriculture. Thus the subject of veterinary education (*Subject VIII*) was from this point of view no less important than that of agricultural education itself. The principal question before the Board was whether it was advisable and possible to raise the standard at one or more selected colleges so as to turn out students who will be qualified for appointment to the higher grades of the

Provincial Service or ultimately to the Imperial Service and to make recommendations as to the best method of reorganizing and administering veterinary colleges and schools. A committee mainly composed of veterinary experts dealt with the question and the Board adopted their report without discussion.

The next subject (*IX*) was that of the value of phosphatic manures in India and the possibility of arranging for the manufacture of superphosphates on a larger scale locally so as to lessen their cost. Though at present there is not sufficient evidence to state definitely that any deterioration of the soil arising from depletion of phosphates has occurred generally throughout India, the importance of phosphatic manures to the various crops has been widely demonstrated by the experiments carried out at Government farms in the different provinces and it was felt that a demand for this manure would come. The Board therefore recommended that a survey of the country's resources in mineral phosphates should be undertaken, that with a view to keep the supply at a price within the reach of the cultivator the control over all the internal mineral sources of supply should be retained by Government, and that the question of reducing internal railway rates charged on concentrated manures should be considered by the Railway Board.

It is generally recognized that the large number of field experiments carried out in the past have not led to such definite results as were anticipated and this caused the subject of experimental error (*Subject X*) to be discussed this year. In a country like India nothing is likely to do more harm to a young department than hasty conclusions and generalizations. Great importance therefore attaches to the comprehensive recommendations made by the Board on this subject.

As regards the proposed collation and publication, for general information, of the useful data on manuring and tillage now available as the result of the experimental and research work already carried out (*Subject XI*) the shortage of staff now so evident in the Department rendered it impossible for any action to be recommended by the Board.

The next subject (XII) of bringing improved methods of agriculture to the notice of cultivators may truly rank as the "popular doyen" of the Department, and though it had remained in retirement for the last four years with a view to recruiting its strength yet even the versatile Dr. Mann who has fathered it from the beginning was forced to admit that the subject has not increased in weight since it was last seen at Coimbatore in 1913. No important new method had been evolved since then and the Board satisfied itself with making recommendations as regards the extension of the methods at present in vogue only in certain areas. The Board recommended that where district boards employ district agricultural inspectors to tour villages, advising on seed selection, tillage, prices, etc., they should be members of the subordinate staff of the local Agricultural Department deputed for the purpose and should work under the direction and supervision of the Agricultural Department; that co-operative organizations should be widely utilized for demonstration purposes and where these do not exist steps should be taken to create them; that *taccavi* loans for agricultural purposes and improvements should be granted on the recommendation of the officers of the Agricultural Department; and that the system of appointing trained cultivators, such as the *Kamdars* employed in the Central Provinces and other provinces, as local demonstrators of agricultural improvements, should be widely extended.

The necessity for legislation regarding the sale of fertilizers (*Subject XIII*) was next taken up. It was considered by the Board in 1906 and again in 1907 and the conclusion then arrived at was that the time was not ripe for the introduction of legislation, but the desirability of maintaining a special watch over the development which might take place in their use was recognized. The use of artificial manures has spread considerably in this country during the last decade and the planter as well as the ryot requires protection against adulteration. The Board therefore considered that the time has now arrived for the introduction of legislation to regulate the sale of fertilizers

Subject XIV aroused a good deal of interest owing to the fact that a world's food shortage is at present being experienced and

though the primary function of the Agricultural Department is the increase of yield yet the necessity of accelerating the pace of increased production is evident to all. That the shortage will continue for a long time even if peace is restored soon is now almost a certainty, and that India can take a large share in relieving this shortage cannot be denied. It was recognized that the bringing of waste areas under cultivation or increasing the area under foodstuffs are administrative questions. The methods which come properly within the scope of the Agricultural Department are the introduction of improved varieties, manures, and better cultivation, and the Board showed itself fully alive to the question before it.

Though the problem of putting the cane sugar industry on a sound basis (*Subject XV*) has been discussed at each meeting of the Board since the year 1911, it has assumed since the beginning of the war an interest of its own as the prevailing high price of sugar has given India an opportunity to considerably improve her position in this industry. The Board of 1917 was notable for a definite step in this direction being advocated in the creation of a sugar bureau. It also recommended the opening of a sugar station in Bihar and also in Assam and the extension of experimental work on the subject in Burma. Some of the facts given by Dr. Barber in his comprehensive review of the situation showed clearly how the question of a bureau has become one of immediate urgency. While the Department is continuing work on the introduction of the new varieties of cane, of better agricultural methods, and of improved manufacturing processes, the need for a central authority to correlate all the accumulated facts for the benefit of future workers has become acute and in our opinion the Board could have gone further and advocated the creation of a committee to tackle the whole subject of the industry at this the most favourable opportunity possible. Dr. Barber's claim that the problem of producing the seedlings suitable for North Indian conditions, under which the largest area under sugarcane lies, is in a fair way to being solved was borne out by the series of seedlings which were exhibited in the Board's room. It is easy to realize the immense importance of this

success, if it fully materializes, in the development of a really healthy sugar industry in this country.

The necessity for investigation into the water requirements of crops (*Subject XVI*) followed. When we take into consideration the large area under irrigation at present and its extension in the near future, the importance of the investigation as to how the water can be used to the greatest advantage and with the least possible damage to the soil will at once be apparent. Dr. Leather on the chemical and Mr. Howard on the agricultural side have both gone into the subject, while agricultural and irrigation officers in the provinces have made some important observations; but all this scattered information needs to be put together and further investigations are necessary. The Board therefore resolved that a special Imperial officer of agricultural experience with a suitable staff be appointed to investigate the water requirements of crops and that an experimental station or stations be selected for this research work by the staff after it has been appointed.

The last day of the Board's sitting was devoted to agricultural education (*Subject XVII*) and this let loose a flood of eloquence which had been pent up by the technicality of the previous subjects. Never was it more clearly shown that every one has an opinion on education and the Board was very emphatic in the expression of its views. "A sound system of rural education based on rural needs is essential," "the present system is wholly inadequate," "revolutionary improvements are needed in the system of rural education," "there should be co-operation between the Education Department and the Agricultural Department in effecting necessary changes," "the provision of the necessary funds should form the subject of an immediate, careful, and detailed examination by the various provincial administrations," are some of the phrases occurring in the resolutions. A couple of clever speeches by Mr. Biss, the educational expert detailed to shepherd the committee, did much to bring home to the Board the lines on which he thought the soundest progress could be made. With Mr. Higginbottom advocating the fulfilment of everything in the next five minutes, Mr. Clouston in favour of slowness because it was slow, Dr. Kunjan Pillai asking

for the millennium based on the present system of education while Dr. Coleman demanded a thorough overhaul of the foundations, the Board listened to a debate of a class rarely heard before. One cannot help thinking that possibly the choice of the Council Hall had much to do with this unwonted eloquence which formed a fitting termination to the most successful meeting of the Board yet held. It was sad to feel that the familiar faces of Col. Pease, Dr. Barber, and Mr. Gammie would be missing from the next meeting, and the President in bidding them farewell expressed the feelings of all. The opportunities for seeing the Agricultural College, the adjacent farms, and the work of the Bombay Department in and around Poona, the arrangements for the meeting, the camp and the mess at the Gymkhana Club, coupled with the general amenities of the station, made the 1917 meeting a very pleasant one to all concerned.

IN MEMORIAM.

LIEUT. E. J. WOODHOUSE, M.A., F.L.S.

IT is with deep regret that we record the death of Mr. E. J. Woodhouse, late Principal of the Sabour Agricultural College and Economic Botanist to the Government of Bihar and Orissa.

Mr. Woodhouse was educated at Marlborough and Trinity College, Cambridge, and joined the Indian Agricultural Service in 1907 as an Economic Botanist. In 1911 he was appointed Principal of the Sabour Agricultural College and held that post till in 1915 in response to the call of duty he joined the Indian Army Reserve of Officers.

He has now made the supreme sacrifice, having died of wounds received in action on the 18th December, 1917. *Dulce et decorum est pro patriâ mori.*

As a member of the Department Mr. Woodhouse was a Botanist of very high abilities and with much enthusiasm for his work. Amidst the heavy duties of organizing the Sabour College he found time to do a considerable amount of botanical and entomological work of real and lasting value. Personally Mr. Woodhouse had a peculiar charm of manner which endeared him to all. His untimely death has robbed the Department of a young officer of great promise, but he died as he would have wished—a soldier's death.

In Memoriam.

The late Lieut. E. J. Woodhouse, M.A., Dip. in Agri. (Cantab.), F.L.S.

Dulce et decorum est pro patriâ mori.

TESTING NEW CANE SEEDLINGS IN NORTH INDIA.*

BY

C. A. BARBER, Sc. D., F. L. S.,

Government Sugarcane Expert. Madras.

THE work at the Cane-breeding Station at Coimbatore has now reached a stage when a closer connection is needed with sugar-cane farms in various parts of India.

The object aimed at in founding the station was to obtain better varieties of cane than those at present grown in India. But this is complicated by the fact that these canes are divided into two very well-defined classes—thick tropical and thin indigenous ones—which have to be dealt with separately. There are already many excellent thick canes in the country, while the thin ones are generally of very inferior quality, but numerous seedlings have been obtained in both classes.

To obtain thick cane seedlings of promise is merely a matter of routine, and a large number have been raised, some of which it is hoped will be of value in agriculture. The raising of the thin seedlings, or such as would be needed to replace the indigenous class, is much more difficult, and, because of the much greater area under these, their production has received most attention.

* A Note submitted to the Tenth Meeting of the Board of Agriculture in India held at Poona in December 1917.

The following is an approximate summary of seedlings considered suitable for North Indian conditions, which have been obtained each year up to the present time :—

	Probably suitable	Number of seedlings grown to maturity	Total number of seedlings raised
1911-13 ...	0	48	48
1912-14 ...	3	2,067	10,000
1913-15 ...	4	2,400	20,000
1914-16 .	10	3,400	30,000
1915-17	15	4,100	30,000
1916-18 .	(100-300 ?)	4,800 not yet analysed	99,000

From this table it is seen that, with the current cropping season, there will be a great expansion in the number of seedlings considered suitable for North India, and there is every prospect of this number being steadily kept up each year in the future. The number of seedlings raised this year and now approaching maturity, which may produce varieties of value under North Indian conditions, is 2,800. These are chiefly crosses between thick tropical canes and hardy Indian ones, or "rogues" of thick canes. And it is worth pointing out that we have in the seedlings raised also made a distinct advance to the solution of the problem of obtaining varieties suited to the very different conditions in North Indian sugarcane tracts. Taking, for instance, three canes as typical of such tracts, *Katha* for the Punjab, *Saretha* for the eastern portions of the United Provinces, and *Pansahi* for Bihar and the contiguous part of the United Provinces, we have the following seedlings growing :—

Punjab, 200 seedlings obtained by crossing *Katha* and *Kansar* with thick canes. We shall probably obtain, from these, 20 varieties worth trying in the Punjab, while some of the next series will also probably be worth considering.

United Provinces, 800 crosses between *Saretha* and thick canes, which are likely to yield at least 50 worthy of further trial.

Bihar, 600 crosses between *Pansahi* and thick canes, from which we may reasonably expect 40 varieties suitable to the Pansahi tract.

Our recent success is mainly due to two causes—the more effective control of the flowering of the cane varieties, and a careful discrimination of suitable "mothers." A further factor is the use of "rogues" as parents. In each crop of thick cane seedlings there usually occur a small percentage of seedlings differing entirely from their parents and simulating the thin canes of North India. These are very vigorous but of low sucrose content; they flower very readily, have abundant pollen, form seedlings in profusion, and flower earlier than the indigenous canes and more or less at the same time as the thick canes. They have been freely used to cross with good thick canes, and a large number of seedlings have been obtained by this method.

This portion of our work thus also enters the routine stage, and it becomes necessary to consider the best means of testing the fitness of these seedlings in the field.

It must be emphasized that the work on the Cane-breeding Station is very different from that in tropical sugar countries where only thick varieties are aimed at. A yet more important difference is that the seedlings are wanted for places whose climate and soil are very different from those at the station.

While the Cane-breeding Station is eminently suited for obtaining masses of cane seedlings, the first object aimed at, it is poorly equipped for testing these seedlings afterwards. Although constantly being improved, it has no good plantation land, and the sucrose in the juice varies a good deal from year to year in the same seedling or variety. This variation will be seen from the cases selected below :—

	1913-14	1914-15	1915-16	1916-17
	Per cent.	Per cent.	Per cent.	Per cent.
M2 ...	13·18	12·21	13·40	10·17
M21	12·50	15·07	13·96	12·59
M45	15·81	11·74	15·55	12·74

There are similar, though less pronounced, differences in vigour year by year, partly due to rainfall and partly to the part of the farm on which the seedlings are grown.

The sucrose readings on the Cane-breeding Station, as already pointed out elsewhere, are also low:—

	Cane-breeding Station Per cent.	Central Farm, Coimbatore Per cent.	Jubbulpore Per cent.
Thin canes M2 ..	12·21	14·58	15·21
M19 ...	13·26	16·75	12·74
M45 ...	11·74	17·78	14·71

	Cane-breeding Station Per cent.	Palur Farm Per cent.	Dacca Farm Per cent.	Jorhat Farm Per cent.
Thick canes B147 ...	15·88	17·73	16·47	17·59
B208 ..	16·76	19·93	18·62	17·77

Arrangements are already being made whereby the thick cane seedlings will be tested elsewhere, and a piece of land is being acquired in the neighbouring wet land area for the furtherance of this part of the work. For testing the thin cane seedlings and those obtained by crosses between thick and thin varieties, it is proposed to enter into negotiations with certain North Indian provincial stations where there is the chance of accurate chemical control, drafting successive series of likely seedlings to them for further growth. There should be little difficulty in growing, say, 50 seedlings in rows on such farms, and testing them as to vigour and sugar-content.

This is a change of policy from that laid down. It was proposed to grow the seedlings for three years on the Cane-breeding Station before distributing them. But the exceedingly variable results obtained in successive years render this a waste of time, as we are sometimes altogether doubtful after the three years as to the relative value of the seedlings grown, and we have reason to suppose that their behaviour elsewhere will be quite different.

The seedlings thus far grown to maturity are numbered "Madras, 1—17,000." These figures will increase year by year and are cumbersome. Besides this, confusion has already arisen between Madras seedlings and Mauritius seedlings grown in India, such as Maur. 1237, 55, 15, 16, 30, 33, 131. It is suggested that a new series of numbers be started of such canes as are, after testing in the Provincial farms, considered worthy of trial by the ryots in

the field. These will obviously be far fewer, and the numbers will be much easier to deal with and remember. The new series may be named after the Cane-breeding Station and termed "Coimbatore Seedlings" (Co. 1, 2, etc.).*

It is proposed to commence this distribution during the current season with, say, a dozen varieties, and this will be followed later on by others as the first ones are rejected. Suggestions are invited as to which Provincial Departments will agree to co-operate with the Sugarcane Expert and enter into this arrangement.

(A demonstration of the various classes of seedlings that are being raised was made at the Meeting of the Board of Agriculture at Poona.)

APPENDIX.

The following circular has been issued with the seedlings since distributed from the Cane-breeding Station:—

Owing to our success in the past two seasons in obtaining desirable crosses between tropical canes and thin Indian varieties, it has been decided to start a tentative distribution of some of these to Provincial farms. As there are fourteen or fifteen of the latter who have intimated their desire for seedlings, the material available is unfortunately small, but it is hoped that this will not recur. In sending these out a certain amount of selection has been made, those for the Punjab, for instance, differing markedly from those for Bihar in parentage, thickness, and early ripening. It is important that the period of testing should extend for several years, because it takes some time for a seedling to accommodate itself to the vegetative mode of reproduction, as well as to acclimatize itself to the very different conditions of soil, temperature, and moisture in its new surroundings. As an instance, a certain cane was distributed because of its rich juice; it refused to grow more than a couple of feet in length for the first four years, but was kept on because of its juice; in this the fifth year it has suddenly grown

* On further consideration it appeared best to attach Coimbatore numbers at once to the seedlings selected for distribution this year, as the proposal to alter the numbering after distribution would be unworkable. This has accordingly been done.

well and the juice does not seem to have suffered by the change. There are numerous instances, in the Indian experience of the past twenty years, of such gradual acclimatization.

We have from time to time obtained a series of Java seedlings specially selected for Indian conditions and as these are now receiving marked attention and have given good results, especially in Shahjahanpur, Mysore, and the Central Provinces, the new Madras seedlings should be compared with them. These Java seedlings are therefore widely distributed for this purpose, besides their own intrinsic merit. They have been in the country for six to seven years and have been grown on the Cane-breeding Station from its start, and are most of them at least twenty years old. It is important, from what has been said above, that this should be borne in mind when they are compared with the Madras seedlings.

It is hoped that the results obtained in different places will be communicated in due course, as this will enable us the better to judge what class of seedlings is likely to succeed in different parts of the country. The Madras numbers (of seedlings grown to maturity and analysed) will this year considerably exceed 20,000, and as these figures are cumbersome it has been decided to institute a new series for such as are being distributed, "Coimbatore" taking the place of "Madras." These numbers will commence with the present distribution. The six seedlings sent out four years ago were intended to act as a guide to the growth of Madras seedlings in different parts of the country, and, having now served their purpose, may be discarded.

THE TREND OF INDIAN AGRICULTURAL EXPORTS.

BY

A. C. DOBBS,

Deputy Director of Agriculture, Chota Nagpur.

THE distance of India from the principal ports of Europe and the reduction of shipping facilities have combined with the development of trade across the Pacific to lessen the effect of the war on Indian agriculture. The tracts that produce wheat, cotton, sugar, and indigo have no doubt benefited by the higher prices of those staples, and their area has been extended at the expense of oilseeds, the value of which has fallen, but the general ratio of prices of the ryot's produce to those of his requirements has not seriously changed, nor has the general level of wages risen owing to the diversion of any considerable amount of labour to military occupations. On the other hand, the war has undoubtedly interfered with, and in fact almost temporarily arrested, the normal secular change of prices that has been in progress since the first railways were made in India. When normal conditions are restored, there is every reason to suppose that this secular change will be resumed and intensified, and a few speculations as to the nature of the change, and its probable scope in the near future, may therefore be of interest to a Department which must look forward a decade for the results of its activities.

The contrast between India as an agricultural country and the western industrial world is marked, and is likely to remain so until coal becomes a minor factor in industrial production. As long as coal remains the all-important factor in raising and maintaining the standard of living above the point at which the necessary minimum

of food and warmth is assured to all, so long will India remain primarily agricultural in character as compared with countries where coal is relatively abundant. Before the use of coal when the production and distribution of food was effected entirely by the consumption of a portion of the food produced, periodical war or famine were alternatives which a settled population had perforce to contemplate. The fear of famine has recently been almost exorcised from India, and her resources in coal and other forms of power are probably sufficient to enable her to maintain an efficient system of communications at a cost which, in view of the density of the population in cultivated tracts, is likely to compare favourably with the cost in countries where the population is more diffuse. But beyond this, it seems probable that industrial organizations on a large scale will be limited to the few places that are particularly favoured in the matter of supplies of power and raw material—a generalization that is supported by the exceptional prominence of the few great non-agricultural industries in India, such as the Kolar gold-fields, the Sakchi steel works, and the Bombay cotton and Calcutta jute mills.

This being so, the influence of industrialism on India is likely to be, so far as the near future is concerned, mainly external, and the sufficiency of the coal supply for purposes of internal transport will only serve to accentuate the contrast and intensity the reaction between foreign industries and Indian agriculture.

The nature of the effect on Indian agriculture can be judged from the change that has already taken place since the opening up of the country by railways—the extension of the cultivation of a limited number of great staples for export. Cotton, wheat, jute, tea, groundnuts, and other oilseeds almost exhaust the list, but the effect of their export in raising prices and wages in the districts concerned is already very considerable.

There are two ways in which the war is likely to affect this development. Firstly, by converting Europe from a creditor to a debtor continent it will inevitably cause an outward pressure of population towards other temperate areas, and thus lead to more intensive cultivation of vast expanses of hitherto only half-farmed

land in those areas. Secondly, it has already led to a crystallization of industry in huge organizations which will be developed on lines that are far more economical of labour than has hitherto been the rule outside America. The population of Europe will spread over the temperate areas, and the standard of living of the majority will rise very rapidly. It is quite possible that—measured in the products of industry—wages and the value of food, fuel, and agricultural products, among nations of European stock as well as in Japan, will have doubled between the years 1914 and 1924.

India will get her cloth and imported machinery and manures at a less cost in terms of her agricultural exports, and the ryot will have a greater inducement to grow staples for export after his own food requirements have been met.

From the point of view of the Agricultural Department, the important point is to recognize the growing importance of export staples, and to anticipate, as far as may be, the demand for such agricultural products as seem likely to pay best under the new conditions. There are innumerable small crops—inferior millets and other cereals, and pulses—which give small yields and are now grown at considerable labour for local consumption ; it is reasonable to suppose that with prices of crops, which give a much higher money return, rising, as compared with prices of artificial manures and implements, the area of those smaller crops will decrease indefinitely.

On the other hand, there will be a growing demand for such tropical and sub-tropical products as coconuts, rubber, tea, coffee, cotton, and oilseeds of all kinds.

The great variety of species of plants cultivated in India under special conditions for local consumption is likely to give way to an equally great variety of races of fewer main species of commercial importance, the value of which will be fixed by world standards instead of by local peculiarities of soil and market.

More detailed speculation with regard to this general proposition should enable workers in each main agricultural tract to pick out with some assurance the crops to which special attention should be given, but there are one or two fundamental factors of the European demand which narrow down the enquiry considerably.

First comes the question of freight; bulk for bulk, and weight for weight, the most expensive products will of course bear the cost of freight most lightly, and of non-perishable staples not already exported those that have the highest inherent value are most likely to find a market abroad. Secondly, there is the probability that the northern races will increase the out-turn of the staples of the temperate areas and rely on southern latitudes chiefly for the products that suit the characteristic climates of the tropics and sub-tropics. Apart from such purely southern products as coffee, tea, coconut, rubber, and cotton, there are a large number of crops grown in India which require a definite warm dry period in which to mature their seed. The more important of these are pulses and oilseeds. These crops have been comparatively neglected in India, but they have a peculiar value in view of a growing trade with the temperate areas, because, with the exception of milk and meat for the production of which those areas are specially adapted, very few nitrogenous and fatty products are grown in northern climates, while the intensive production of meat and milk requires the feeding of cattle on a relatively high nitrogenous diet. The nitrogenous and fatty constituents of cattle foods cost in England about three times as much as starches and sugars, while in India the difference is much less; and this fact, combined with the inherent calorific value of fats and oils, which is nearly $2\frac{1}{2}$ times that of starch, assures an increasing external market for Indian pulses and oilseeds as compared, for instance, with rice which consists almost entirely of starch, or wheat and barley which can be grown as well or better in temperate climates.

From this point of view, groundnuts are likely to become even more important for export after the war; and the varieties of soybeans which are the chief, if not the only other, leguminous oilseeds should not be lost sight of; while anything that can be done to increase the area of pulses in general, will go towards maintaining the fertility of the land in the face of the drain that the export of non-leguminous oilseeds undoubtedly causes.

Hitherto the Agricultural Department has devoted itself chiefly to increasing the out-turn of the three crops that are perhaps

more exhausting than any others—cotton, wheat, and sugarcane—and the suggestion may be hazarded that the introduction of mineral manures for leguminous crops, combined with the selection of heavy yielding varieties that can be grown and harvested with a minimum of labour and risk, is both essential if the fertility of Indian soils is to be maintained at the level required for the continued production of the improved staples already introduced by the Department, and is likely to be more directly profitable in the near future than any other line of work.

AN ACCOUNT OF SOME EXPERIMENTS IN LUCERNE CULTIVATION AT SAHARANPUR REMOUNT DEPÔT.

BY

MAJOR J. BRUCE,

Army Remount Department.

ALTHOUGH one of the most valuable fodder crops of warm climates, lucerne is little grown in India, except on Government farms, or as a market garden crop in the neighbourhood of cantonments. Even in these instances the area cultivated is comparatively small. The reason for this is that lucerne is supposed to need an excessive amount of water which can be utilized more profitably in irrigating a larger area of other crops.

In Remount Depôts lucerne is usually grown by the ridge system, on the ground that it will not survive the rains when sown on the flat. Ridges look nice, and any losses are quickly and neatly repaired by fresh sowings in the autumn ; but in some climates these losses are considerable, and the sowing returns for the last 15 years show that at Saharanpur lucerne is at best a biennial. The question therefore arises whether it might not be more profitable to grow it broadcast as a rotation crop, and thus make use of its well-known manurial properties. By this system the labour of making and maintaining ridges would be saved, and the cost of cutting reduced, while, should it be found to yield a good return with few irrigations, the area under lucerne cultivation might be largely extended.

In November 1916 a series of experiments were started in this depôt in order, firstly, to ascertain whether lucerne would grow

successfully with a small amount of water; and, secondly, to test the respective merits of the ridge and broadcast systems. Eight plots were laid out—three ridged and five broadcast—on sandy loam soil. By an unfortunate mistake an excessive quantity of seed was sown in the broadcast plots, and although this greatly lessened the value of the experiments, the results are nevertheless interesting.

The ridged lucerne was treated in the usual manner, except that water was restricted. The broadcast received one hand weeding when the plants were small, and all subsequent cleaning was done with harrows. Cuttings were usually made by sickle or scythe, but the whole crop was *cheeled* (scraped) three times—twice before the rains to eradicate dodder, and once in November to clean the ground.

Although none of the plots received more than eight waterings during the twelve months, the plants did not appear to suffer from lack of moisture, and the losses incurred may be ascribed to three causes:—Firstly and chiefly, to the steps taken to eradicate dodder, more especially in plots 2 and 3; secondly, in plots 2 and 5 to too deep cultivation; and thirdly, to some extent to water lodging during the rains.

Since no weeding or harrowing was done in the rains, it is necessary to make an allowance for grass. The following estimate which is based on tests slightly favours the grass at the expense of the lucerne:—

Plots 3 to 8 (sown on fallow land). For July, August, September, October, 3 parts grass to 1 of lucerne. For November $\frac{1}{4}$ grass.

Plot No. 1 (sown on site of old lucerne garden). For July to October $3\frac{1}{2}$ grass to 1 lucerne. For November $\frac{1}{3}$ grass.

Plot No. 2. For rains $\frac{4}{5}$ grass and for November $\frac{2}{3}$ grass.

During the rains the lucerne was cut whenever the grasses appeared to be getting too strong, and the mixed crop was made into ensilage, which has proved of excellent quality. After every

cutting the lucerne was the first to recover, and had made a good growth before the grass began to overtake it.

In the early summer dodder attacked the lucerne very severely, and it was feared that the whole crop would be lost. Digging out was first tried, but the parasite was too widespread for this remedy to be effective. Burning litter on the affected areas was next tried; widely in plots 2 and 3 and to a less extent in other plots. The results were disastrous to the lucerne. Finally, at the suggestion of Major Hewitt, A. R. D., *cheeling* (scraping) was resorted to, and this proved successful.

As very full information is given in the statement at the end, only a few remarks on each plot will be necessary.

Plots 1 and 2 were sown on land where lucerne had died a few months previously. Grasses appeared in them early and they were throughout less clean than the other plots.

Plot No. 2 had been ruined in the attempts to eradicate dodder, so at the end of May it was given a thorough and deep cross cultivation to see if this would clean it. The grass had been established too many years, however, to suffer any permanent damage, and the only result was the destruction of more lucerne.

Plots 3 to 8 were sown on fallow land and were clean until July when rain grasses sprang up thickly, and *dub* (*Cynodon dactylon*) made its appearance.

Until May, No. 3 which had been seeded 40 lb. per acre was by far the best plot, but, like No. 2, was ruined by the burning and digging to get rid of dodder.

Plot No. 5 only received five waterings during the twelve months, and produced 71,722 lb. of green fodder per acre, of which 42,784 lb. are assessed as lucerne and the balance as grass. In May, half the plot was deeply cultivated to see whether a thorough stirring of the soil would strengthen the growth. The experiment proved a failure and resulted in a permanent reduction of 25 per cent. in this half of the plot.

Plot No. 7 was limed some months previous to sowing and eventually produced the largest return.

Plot No. 8 was sown on inferior land containing patches of *kalar* (alkali). It was seeded with a nurse crop of barley, and received no hand weeding; a large mixed crop was cut in February.

At the close of the rains the lucerne in all plots was good and healthy, although the ridged plants appeared bigger and stronger than those on the flat. The thorough harrowing given after the last cutting has, however, been beneficial, and the difference is now less marked. The returns from both systems, even after making the necessary deductions for grass, would be considered quite satisfactory for lucerne grown under heavy irrigations, and the results would have been still better but for the unlucky attack of dodder.

It will be interesting to compare the yields of these experimental fields with those of oats and sorghum, the two winter and summer crops chiefly cultivated in Remount Depôts. The most convenient method of comparison will be to take Kellner's starch equivalent values for each fodder, in spite of the fact that Kellner ascribes a very much lower feeding value to lucerne than do American authors and that Indian conditions probably more nearly approximate to those of America than of Europe.

The average of Kellner's starch equivalent values of green lucerne in all stages is 8·73, of oat hay 35·2, and of sorghum 8·1. His lowest value for grasses is 9·9; this is for good irrigation meadows and would appear to be the most suitable for rain grasses.

From Table I below, it will be seen that the return obtained in these experiments for each acre of lucerne is greatly superior to the combined average yearly yield of one acre of oat hay and one acre of imphee (Sorghum), and, although the seed is expensive, the balance of profit is in favour of the lucerne. The average yield of oat hay in this depôt is 4,480 lb. with a starch equivalent of 1,577; that of imphee is 22,930 lb. with a starch equivalent of 1,857. The starch equivalent value of these two crops together therefore is 3,434. Plot No. 4 gives the lowest yield in these experiments with 60,436 lb. green fodder, having a starch equivalent of 5,572 for the mixture. The yield of No. 7, the best plot, is calculated at 8,000 starch equivalent.

Although these lucerne fields have given large yields with very little water, yet it is not safe to assume that the results would always be similar. The rainfall this year up till July was slightly below normal, but the summer was exceptionally cool, with numerous cloudy days and an entire absence of hot winds. That the conditions generally were unusually favourable is proved by the fact that the average yield per acre of lucerne for 1916-17 throughout the depôt was the highest recorded for 16 years. The experiments, however, are distinctly encouraging and justify further investigation.

TABLE I.

Showing details of out-turn in lb. per acre.

	PLOT NO.							
	1	2	3	4	5 (A & B)	6	7	8
December 1916	231	..	.	..	...	...	.	.
January 1917	256	4,006	8,114	583	3,237	461	.	..
February 1917	...	...	..		2,456	..	3,985	12,262*
March 1917 ...	5,289	6,230	9,520	4,207	7,170	6,588		
April 1917 ...	5,688	10,178	14,867	5,323	9,447	5,956	18,520	14,698
May 1917 . ..	8,354	2,898	1,387	8,277	4,117	9,253	4,855	3,114
June 1917 ...	5,411	782	7,376	5,077	3,963	5,320	7,087	5,719
July 1917	22,279	18,726	15,167	12,379	12,672	3,422	.	
August 1917 ...	.	.				16,867	22,564	13,405
September 1917	13,970	11,777	13 947	10,313	14,963	19,096	16,205	13,427
October 1917 .. .	11,588	9,693	11,720	9,410	9,574	14,351	9,487	8,254
November 1917 .	6,570	5,241	4,453	4,867	4,123	4,337	3,953	2,939
Total green fodder (Lucerne and grass mixed)	79,636	69,531	86,551	60,436	71,722	85,651	86,656	73,818
Deduct for grass	39,397	35,651	31,738	25,293	28,938	41,386	37,180	27,049
Balance pure lucerne .	40,239	33,880	54,813	35,143	42,784	44,265	49,476	46 769
Starch equivalent value of lucerne and grass mixture	7,413	6,487	7,927	5,572	6,600	7,961	8,000	6,761

Average yield of 1 acre Oat hay— 4,480 lb. Starch equivalent = 1,577
„ „ „ „ „ Sorghum— 22,930 „ Starch equivalent = 1,857

Starch equivalent value of 1 acre Oat hay and 1 acre Sorghum 3,434

* Lucerne and barley mixed

Table II.

Showing details of sowing and watering.

Plot No.	System	Area of plot in acres	Date of sowing	Seed sown per acre	Dates of waterings: Nov	Dec.	Jan.	Feb.	Mar.	April	May	June	Total No. of waterings	Out-turn of green fodder per acre
				lb										lb.
1	Ridge	1·99	10th Nov	13	10	5			14	25	26	13	6	79,636
2	Broadcast	2·15	14th ,,	32	14	1			14	9 & 24	8	14	7	69,531
3	,,	1·50	14th ,,	40	14	2			15	11 & 24	28	11	7	86,551
4	Ridge	1·66	14th ,,	13	14	1	1		17	10 & 29	11 & 25		8	60,436
5 (A & B)	Broadcast	1·62	15th ,,	48	16	5			21	26	29		5	71,722
6	Ridge	1·66	15th ,,	13	16	2			19	27	8 & 25	10	7	85,651
7	Broadcast (limed)	1·17	15th ,,	26	16	7			19	4 & 28	5 & 29	13	8	86,656
8	Broadcast (with barley)	1·85	15th ,,	26 lucerne 32 barley	16	7			18	8 & 28	5 & 30	12	8	73,818

Remarks

Rainfall

Month	During the year	Average for 20 years
November ..		0·25
December		0·57
January	0·5	1·37
February		1·10
March ..	0·6	0·81
April ...	0·9	0·45
May	0·7	0·71
June .	2·0	4·17
July	14·0	9·81
August	8·8	9·49
September	11·0	5·95
October ...	6·0	0·66
TOTAL	44·5	35·33

THE SPREAD OF CO-OPERATION IN THE PUNJAB.

BY

C. F. STRICKLAND, B. A., I. C. S.,

On Special Duty in the Office of Registrar of Co-operative Societies, Punjab.

I. INTRODUCTION.

BEFORE the passing of the Co-operative Credit Societies Act of 1904, a few societies had been founded in the Punjab through the zeal of individual officers. Three were created in the Multan District in 1898 by Mr. (now Sir) E. Maclagan and Captain Crosthwaite, and registered in Calcutta under the Companies Act. Five were set up in the present Mianwali District in 1900 by Captain Crosthwaite. Of the latter, four are still existent though lack of supervision has left them weak. Two of the Multan societies have perished, but Thatta Ghalwan, after a long period of work with varying efficiency on a basis of mixed grain and cash dealings, has arisen in new strength. The Panjawar Society of Hoshiarpur District, dating from 1892, was, and still is, an unregistered and unrecognized association, which will be described later.

By the orders of Government the experiment of co-operation was to be tried in the five selected districts of Rawalpindi, Mianwali, Montgomery, Karnal, and Hoshiarpur. In the following year permission was given to include Multan, Shahpur, Ludhiana, Gurdaspur, and the Rupar Tahsil of Ambala; and the number of selected districts was rapidly increased until the principle of limitation was abandoned. For reasons accidental or otherwise, no serious attempt was at this time made in Rawalpindi, which remained virgin soil until 1913. No large success was apparently attained in Mianwali

and Montgomery, though of 15 early Mianwali societies 12 are still nominally or actually alive, and the number registered was at one time twice as great. Karnal proved a failure, and generally speaking has continued to be unpromising: the Registrar in 1905 applied this description to the whole Eastern Punjab. In this statement he generalized too freely, for from 1910 onwards Hoshiarpur which had hitherto lagged behind its neighbours made rapid strides and is now one of the areas in which societies are not only most numerous, but most truly co-operative.

The difference in the rate of progress was largely due to personal reasons. A single-handed Registrar could effect little without keen propagandists, official or non-official: Ambala District flourished under Mr. Gladstone and Gujrat under Diwan Narendra Nath as Deputy Commissioners; Fakir Iftikhar-ud-Din was valuable as Settlement Officer, Hoshiarpur; while Shaikh Firoz Din, Extra Assistant Commissioner in Gurdaspur, and Pal Singh, an enthusiastic Jat zemindar of Jullundur and Lyallpur, were responsible for multiplication of societies in the districts named. It cannot, however, be said that such multiplication was always of real value, and a number of "paper" societies were cancelled without enjoying more than a nominal life.

At the present time the movement has penetrated every Punjab district except Dera Ghazi Khan, and it has been found that no difference of caste or clime renders the Punjabi peasant of the plains or hills inaccessible to co-operative teaching. The least prosperous regions are Montgomery, Multan, Muzaffargarh, Mianwali, Attock, Jhang, Kangra, Gurgaon, the fringe of the province, and including some of its most backward parts. It is obvious, therefore, that only effort and an adequate staff are needed to bring the laggards up to the general level. Most advanced at present are Gurdaspur, Jullundur, and Hoshiarpur, whose growth is shown in the following table:—

	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917
Gurdaspur	...	5	68	59	64	159	202	267	544	585	571	557	555
Jullundur	..	7	44	53	89	197	318	415	453	460	460	461	457
Hoshiarpur ..	3	6	8	11	12	61	122	287	418	452	449	439	43[illegible]

The slight retrogression in 1915 and 1916 is due to an elimination of weaklings and a process of consolidation.

The progress of the Punjab as a whole is given below :—

Year	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917
Societies	12	24	177	258	316	706	1093	1769	2845	3383	3337	3391	3495

II. Types of Societies.

A. Interest was aroused by a scheme adopted in 1892 in Panjawar village of Hoshiarpur District, whereby the entire control and management of the common land was handed over to quasi-permanent trustees, loans being made from the profits of cultivation to redeem the lands and to repay the debts of the co-sharers. The society, though unregistered, has been abundantly successful from the financial point of view, both in enhancing the value of the land and in relieving the associates from embarrassment ; but its proceedings are not in all ways co-operative, since the trustees are not at all times responsible to the members assembled in general meeting and dealings are not confined to members. An association of this nature needs influential leadership ; a single recalcitrant sharer in the common land can block its action : hence the type has not found exact imitators. Certain villages in Sialkot District devoted the entire proceeds of the sale of *shamilat* (co-parcenary) trees on an embankment to their registered societies ; the resulting influx of money available for loans was not in all cases beneficial, and the largest of these societies is under liquidation. Three Gurdaspur societies depend wholly or largely on the income of their *shamilat*.

B. The proposal originally most popular in the Western Punjab was to contribute a fixed or unfixed amount of grain for a period usually of ten years : loans were issued and repaid in either grain or cash. This type was in early years to be found in Mianwali, Muzaffargarh, and Jhelum, and occasionally in Montgomery and Multan : a few specimens in Mianwali and Muzaffargarh survive, but the majority have either faded away or been converted with more or less reluctance to a cash basis. The profits on grain dealing are normally very much higher than on cash payments, without

any hardship to the borrower, on account of the wide divergence between sowing and harvest prices : it is essential that grain be either promptly sold or stored with the utmost care in order to avoid damage and the suspicion of irregularity. A grain basis is acceptable in areas where Mahomedan objections to interest are strong : it offers, however, little inducement to the wealthier landowners, even of the peasant class, whose varied requirements can only be met by a free grant of cash loans both at harvest and at other times.

This "Mianwali" type never received a fair and full trial in the Punjab ; it sprang up in districts where, through accident and intention, staff could not be provided, and the societies had decayed or learned unbusinesslike methods before adequate inspection was available. Under good supervision a society working in mixed cash and grain should serve a valuable purpose both in co-operative credit and in the provision of pure seed.

C. Another attempt to escape from the difficulty of interest among Mahomedans gave rise to the "deposit" type, in which a certain number of members, usually a handful of wealthy men, supplied the funds in fixed deposit for a term of years, taking a share in the profit, which was held not to be interest. The most noteworthy case was the Kharal Fund of Mehrpur in Montgomery District under K. S. Kamir Khan. This society, at one time outwardly flourishing, recently failed, partly because its operations were extended over too wide an area, and partly because on the transfer of the zail (agricultural circle) to another district the local inspecting staff failed to learn of its existence and lend it aid. Societies of this description are fundamentally unsound ; non-depositing members, admitted for a trifling fee, fail to realize their responsibility ; they appear to be only borrowing from tribal leaders as their fathers and grandfathers have done, and no co-operative sense is developed. The principle of paying a share of profits to depositors is maintained in the Ludhiana Weavers' Society, where, however, all members are made to contribute shares.

D. The type which eventually became predominant originated in 1906 in Gurdaspur and other districts of the East Central Punjab,

and is a modification of the Raiffeisen Society, sometimes called the Indian Luzzatti model. Shares are paid in ten annual instalments and, though the value of a share is low, form a large proportion of the capital. The accumulated profits or reserve fund may be used as working capital during the 10 years period. At the end of the 10 years, share money may either be withdrawn, or, in the more recent institutions, left in the society; three-fourths of the profits may be credited to the members. A dividend in cash after this initial distribution was usually allowed by the by-laws, though contrary to the rules of the Local Government; the defect has now been remedied by new Government rules. Liability is unlimited and the control democratic; mutual supervision and responsibility are enforced. Since share payments are annually made, deposits do not reach a high figure in most primary societies in their early years. The rate of dividend is now limited by rule to 10 per cent. in order to combat the profit-seeking tendency, and affluent societies are encouraged to reduce the rate of interest on instalments punctually paid.

E. An old society in Multan District has resolved to abolish interest altogether and recover principal only. Every member will pay a small annual contribution, and in order to compel punctuality and inculcate thrift, a fixed penalty will be charged on debts in arrears, and a fixed bonus paid on deposits. The experiment may prove highly attractive to scrupulous Mahomedans, but can only be undertaken after the accumulation of permanent funds.

F. The prevailing industrial type is that of the weavers' supply and sale society. Yarn is bought from the Weavers' Central Stores and supplied to members at the lowest price; when possible, a shop is opened for sale of the members' finished product. Shares are contributed, but cash loans are now rare. The societies are gradually accepting the idea of distributing profits mainly as a rebate on raw material sold to members and as a bonus on finished articles bought from them. Profits are surprisingly large, though the capital is at present of moderate amount.

G. Little need be said of Central Banks and Unions. The former were in all cases founded by individual shareholders, but affiliated societies are buying shares and taking part in the control, while the admission of new individuals is discouraged.

Unions in the Punjab are financing bodies of limited liability, and at a certain stage of development were found to compete with Central Banks. A number of the less active have now been absorbed, and as they perform little or no supervising duty their number is likely to decrease.

III. The Law, the Rules and the By-laws.

The first Act (X of 1904) was admittedly experimental and aimed only at establishing a system of co-operative credit as the simplest form of the co-operative idea. Its provisions were confined to the minimum required for putting societies on a legal basis, arranging for a certain supervision, and affording scope for the grant of privileges. All further assistance and limitation was to be at the discretion of Local Governments which would notify rules, and of the Registrar who would scrutinize the by-laws at the time of a society's registration. No attempt was made to legislate for secondary or central institutions, or for primary societies aiming at other objects than credit. It was not legal to levy a fee for audit or to devote a portion of the profits to charity. Further, by a curious oversight, the Registrar could refuse to register a society the by-laws of which he considered unsatisfactory, but had no power to control or prevent subsequent modification of the by-laws.

These and some minor defects were remedied by Act II of 1912 (the Co-operative Societies Act) which contemplates all forms of co-operative associations. Even the later Act, however, is couched in general terms and is largely permissive rather than mandatory. All detailed control is exercised through rules and by-laws. The need for a prompt method of land redemption was felt at an early stage, and has been to some extent satisfied by Act II of 1913. The grant of *taccavi* to societies under the Land Improvement Act and Agriculturists' Loans Act has been the subject of recent correspondence with the Punjab Government. It has been resolved

that *taccavi* grants for short terms under the Agriculturists' Loans Act may be freely made, and such advances could no doubt be given either to Central Banks or to Village Societies. Members of borrowing societies will not, however, be debarred from direct access to Government. Advances under the Land Improvement Act will only be sanctioned when the purpose of the loan can be effected and the loan repaid within 3 or 4 years, and when all the members share in the work or the benefit. Societies are to keep separate accounts of sums so advanced.

The chief omission in the present Act (II of 1912) is that of an effectual and expeditious mode of liquidation : a society which has been brought under liquidation has *ex hypothesi* failed in its co-operative purpose, and the co-operative staff are at present heavily penalized for a fault that is only partially their own, by the cumbrous and tedious machinery of law. In practice the duty of liquidation is directly or indirectly fulfilled in most cases by the heavily-worked subordinates of the Registrar or of a Central Bank.

The rules notified in 1906 by the Punjab Government under section 27 dealt to a great extent with Government loans; the discontinuance of such loans has rendered the provision unnecessary. The desired control over amendments of the by-laws was given to the Registrar, and a scheme of arbitration for disputes was devised. At this time it was evidently anticipated that the connection between societies and the Revenue Authorities would be closer than subsequent developments have rendered it : an extract from a society's papers was to be attested by the *patwari*, arbitrators were appointed through the Collector, and the Punjab Government supported a proposal that arrears of debts might be recovered through the agency of the *tahsil*, a provision which, though *primâ facie* attractive to many, would beyond doubt have weakened the backbone of co-operators.

In 1912 a notification was issued permitting the distribution of three-quarters of the accumulated profits in a society of unlimited liability in the form of non-returnable shares after the period prescribed in the by-laws, the old Act having allowed an eventual distribution in cash.

In 1914 the earlier rules were revised, and additional forms and registers prescribed; detailed instructions for the procedure of liquidation were given, though nothing can remove the inconveniences of the existing method. It was also laid down that arbitrators in disputes should be appointed by the Registrar, and from this time the recovery of debts by arbitration became effective though at first sparingly employed. New rules have during the present year (1917) been sanctioned by Government after publication. The chief improvements aimed at are a simplification of the arbitration procedure by rendering an award final, save for the right of appeal to the Registrar, and enabling it to be executed as a decree, and a more exact definition of the powers and duties of the Managing Committee, a body which had hitherto scarcely any legal status. The distribution of profits in cash with a dividend limited to 10 per cent. is permitted in a society's eleventh year, but an increasing body of co-operative feeling is opposed to such distribution in practice, and emphasis is being laid on the desirability of reducing and perhaps abolishing interest on loans.

The first by-laws of a primary society, framed in the urgent haste of a new movement and without the advantage of local experience, were in many respects defective. In spite of section 8 of the old Act which forbade the distribution of profits, the return of shares with profits was allowed to withdrawing members, and societies with this by-law were founded up to a very recent date. Shares were paid often in grain and were usually withdrawable after 10 years. It was also laid down, perhaps by a curious oversight, that distribution of the full three-quarters of the profit must be made, so long as such dividend did not, before the rate of interest had been reduced to 6 per cent., bring in to any member a sum exceeding his former annual contribution of shares. The rate of interest was at first 9 or $9\frac{3}{8}$ per cent., and later, on the creation of Unions and Central Banks, was raised to $12\frac{1}{2}$ per cent., which is now general except in young societies. Members were freely admitted on payment of fees only without shares, a laxity which produced an unfortunate sense of charity among the poorer members.

The payment of old debts was not originally contemplated as an object for which loans might be given; and, when afterwards included in the stated objects, was for a time forbidden to members of Committees: moreover, no person was to borrow more than one-tenth of the capital. These two by-laws were not maintained, and the latter has only recently been revived: the great stumbling block is the selfishness of the Committee whose members frequently borrow over half the available capital. Efforts to prevent this selfishness are made in various ways, but with only moderate success. The newest by-laws render shares not withdrawable at the will of the shareholder: the taking of personal security is compulsory, and a limit is set to borrowings by a register *haisiyat* (register of economic status), fixing the maximum credit of every member as principal or surety. All members must take shares, and in cash only. Loans may be given for any necessary purpose.

It is interesting to note that though the present by-laws only permit the reserve fund on dissolution of a society to be applied to a public purpose or reserved for a future society in the same area, and the old clause allowing the Registrar to distribute it to the members has been cancelled, yet that by-law was not illegal, since the old Act did not forbid the eventual distribution even of the reserve fund proper, while the new Act only forbids it in the case of a registered society.

The first Central Banks were founded and their shares were subscribed by individuals who had often an imperfect realization of the objects in view. Primary societies were not expected themselves to become shareholders, and large dividends were openly or secretly aimed at and occasionally obtained. As societies have acquired understanding and strength, they have been encouraged to join in membership and participate in management; the issue of shares to individuals has generally been discontinued, a limit to dividends has been more strictly enforced, and the superior voting power of large shareholders is being abolished. Any future Central Banks founded in this province are likely to confine their membership entirely or principally to societies, and a Central Bank for the Murree Tahsil of Rawalpindi is being incubated in this shape.

IV. Direct Help from Government.

The privileges conferred by the Act itself need not be here discussed. In all countries certain simplifications of the law have been devised in order to free the unlearned peasant and artisan from technical difficulties and to give a society a statutory existence, while requiring fewer formalities than from more advanced and wealthy incorporated boaies.

Government has, however, taken direct action under section 28 by exempting the funds of societies from income-tax, and their documents from stamp duty and registration fees. Section 27 of the Act had already exempted many documents from the necessity of registration.

It is generally recognized that while the subordinate staff of audit and inspection should be paid, and, as societies mature in wisdom, controlled by co-operators, a certain amount of superior supervision should be maintained by Government, which cannot afford to trust entirely to private agency a movement so nearly and deeply affecting the welfare of the poorer classes. The services of the Registrar and his Assistants are lent by Government; and except during a short period in 1915 and 1916, when four Inspectors were paid from the contributions of societies, all Inspectors have been employed at the public expense. In special cases, such as the founding and management of industrial societies, or the extension of the movement to Muzaffargarh District where the relations of zemindars and moneylenders had become more than strained, extra inspectors have been supplied above the ordinary scale. Similarly nine sub-inspectors were for a time provided by Government in new areas. It has recently been decided that in future inspectors will be Government-paid, while societies alone must contribute the salary of sub-inspectors. Small grants are occasionally made to pay for secretaries in the societies of illiterate menials.

By a welcome concession of the Government of India, societies are allowed to use Remittance Transfer Receipts and Cash Orders when despatching money to one another: and an experimental

sanction for five years to a rebate of annas 12 in the rupee of money order commission-charges on similar remittances will enable payments from and repayment to Central Banks to be made without summoning representatives of village societies to a remote centre. The privilege of depositing a cash box in the Treasury has been found convenient by some urban societies.

Before the creation of central institutions, Government loans were given to primary societies, but have been discontinued for some years on the growth of Central Banks. During the financial crisis of 1914, and later owing to the stress of war, temporary advances have been allowed to Central Banks and Unions. The total of Government money (in rupees) held at the end of each year by primary and secondary societies, and the proportion borne by such money to the working capital, is shown in the following table :—

1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917
..	3,700	47,300	93,350	103,959	90,519	76,934	73,976	67,558	63,575	128,529	207,639	133,766
...	10·0	18·1	19·4	14·2	5·7	2·5	1·3	0·7	0·5	0·9	1·0	0·7

During the current year a scheme was prepared for a large advance of Government money, whether in the form of *taccavi* or otherwise, to a Central Bank or to primary societies in Montgomery District, where the colonists of the Lower Bari Doab Canal, though incurring debt and in need of co-operative help, do not own their land and can only offer a mediocre security. After some discussion the proposal was abandoned as Government found it necessary to impose in the public interest more stringent conditions as to security, and were able to permit a less unfettered control than was considered desirable in a co-operative movement. The funds are being successfully contributed by co-operators in Montgomery and other districts.

The sphere of Government assistance in India lies in the work of propaganda, organization, and supervision. In the initial stages of a new movement the authority and approval of Government are valuable and essential ; at a later stage direct support gives way to guidance and correction. Subsidies continued when no longer

indispensable will weaken the spirit of self-help, and the accompanying control may hamper free movement. Particularly in this country the excessive use of official agency tends to create confusion in the minds of the ignorant. Government money is regarded as *taccavi*, to be repaid only under compulsion: the society is frequently called a "Government Bank," and the most strident denials fail to remove this belief when firmly rooted. It is, however, probable that an increasing demand for assistance in staff and funds may arise when Central Banks undertake, as they should, the organization of travelling lecturers, of co-operative periodicals, and of experimental ventures in new co-operative forms. When industrial societies of artisans extend their dealings to a wide field, expert advice and practical help will be needed which the societies cannot at first repay. Cattle insurance in an untried area where statistics are not available is exposed to risks which Government will be wise to share. In all co-operative matters the activity of Government naturally increases as the edifice rises higher, but should be as little as possible in evidence to the uneducated mind.

(To be continued.)

SOME OBSERVATIONS ON AGRICULTURAL WORK IN EGYPT, AMERICA, AND JAPAN.

II. America.

BY

W. ROBERTS, B. Sc.,

Professor of Agriculture, Lyallpur, Punjab.

(Continued from page 587, Vol. XII, Part IV.)

I was in the United States of America from August 15th to October 5th (1916), *i.e.*, about eight weeks, practically the whole of which I spent in the cotton-growing tracts in the south and in the irrigated areas of Arizona and California where the climatic conditions of cotton growing correspond closely to those of irrigated North-Western India. Government agricultural activity in the States may be divided into two main branches, *viz.*, Federal work, under direct control of Washington, and State work, each State having a separate agricultural department of its own. The Federal Department, in addition to ordinary agricultural research work, also extends its activities to such subjects as investigations in road-building and rural engineering for which £55,000 are allotted annually, Forestry with £1,160,000 and Forestry investigations with £60,000, and Meteorology with £40,000. Market organization has £50,000 and Cotton Standards work £12,000 with £35,000 for Enforcement of Futures Act. The total budget of the Federal Department is £5,000,000. To give an idea of the expenditure and size of State Departments, I may quote the case of Texas where the number of experts employed is 285, or more than the whole of the higher grades of the Agricultural Department in India, both Provincial and Imperial. Of the above number it should be noted that 20 belong to the Federal Department and 101 Demonstration Agents are

paid jointly from State and Federal funds. I spent seven days at Washington interviewing Chiefs of Bureaus and especially every one doing work on cotton. The most interesting feature there to me was the Market Organization Division where the cotton standards are prepared. I spent all my spare time in this section and in the Bureau of Plant Industry.

Cotton standards. The cotton standards are prepared on colour or grade, and consist of nine classes, four above and four below the middle or medium class. No standards for staple have been prepared as yet. These cotton standards, of which a large number of duplicates have now been made, are utilized in settling all disputes with regard to the Cotton Futures Act and are accepted by the whole trade for purposes of settling differences in contracts. The successful working of this seemed to me the finest thing I saw regarding the achievements of the American Department of Agriculture. I made a point of asking the opinion of leading members in the various cotton exchanges as to how these worked, and was told on three separate occasions that my informer himself had been chiefly responsible for the types settled upon : this struck me as a great compliment to the Department.

Controlling crop pests, etc. While a great deal of admirable research work was in progress and a staff of experts were on hand to investigate any new disease, there was practically no organization for controlling or stamping out any crop pest, which would be of direct interest to India. The legislative measures taken, however, on the recommendation of the Bureau, with a view to preventing the spread of disease (*a*) from foreign countries and (*b*) from one State or part of a State to another, seemed admirable. With regard to (*a*), special precautions have been taken to guard against the introduction of cotton diseases. The United States of America imports about 50,000 bales of Indian and Chinese cotton annually. In order to prevent introduction of disease, all this has to be fumigated in large fumigating chambers under Federal supervision. One such fumigating plant was inspected by me near San Francisco. It was a small plant, but could do 50 bales at a time. The fumigating chamber consists of a large iron drum into which the cotton bales

can be run on rails. A small engine and suction pump are used to exhaust the air after the chamber is full of cotton. Hydrocyanic acid gas is then let in, and after a definite exposure the cotton bales are taken out. The method has been carefully tested and is very simple and reliable. In view of the fact that up to recently India has been importing American cotton through which we run the danger of boll-weevil and other diseases which have done so much damage in the States, it seems very desirable that a similar arrangement should be put forward in India. The cost per pound of cotton is extremely small, so that there would be no hardship; what little there is, would act favourably for American cotton grown in the Punjab. As pointed out earlier in this report, Egypt has adopted the more drastic remedy of totally prohibiting the import of Indian cotton to that country. As regards (*b*) above, a tract where disease has appeared is declared infected, and export of that produce to non-infected areas, either in bulk or for seed, is either prohibited or allowed only after proper fumigation and examination by Government Inspectors. Had this matter been taken up in India, it might have been possible to restrict the potato moth, *e.g.*, to Western India where it first appeared. It is now doing a great deal of damage in the Punjab.

Soil surveys. The work carried on in this Bureau is of great general interest and is characterized by a broad and well-defined policy, which quality I find often lacking in many of the activities of the Department. A soil survey may be carried out on a number of different principles, and unless they are conducted in accordance with a general scheme, surveys are liable to convey accurate information only to their author. In view of the future importance of this subject, I would suggest that the Government of India should have a definite policy drawn up by the agricultural chemists, so as to make surveys carried out in the various provinces generally intelligible and comparable for the whole of India.

Cotton cultivation. The cotton belt is remarkable for the concentration of the cotton area—often one sees miles and miles of practically nothing but cotton. In many States there did not appear to be any rotation; and, generally speaking, other crops grown

were poor. This is especially so in tracts where Negroes do all the cultivation. This state of affairs, where so much attention is given to one crop, may be unsound economically ; but has certainly led to a very high state of perfection in the cultivation of this crop. Some of the instructive points gathered from conversation with a large number of planters and Negroes are set down below :—

1. When discussing a crop in the field, the cotton plant was generally looked upon in three sections, *viz.*, " bottom," " middle," and " top." A planter would often point out a field as having no bottom crop, *i.e.*, no bolls on the lower parts of the plant, or again the middle crop may be poor or absent ; and then the whole gamble is on the " top crop," the success of which depends on a late fall. Constant references were made as to the undesirability of excessive vegetative growth. All cotton is sown in lines, and the distance between the lines is generally five and a half feet. I saw many fields where it was six and others where it was under five feet. The distance advocated by the Punjab Department for American cotton is three feet. Most intelligent planters in the States and agricultural officers admitted closer planting could give a better crop, but owing to the high cost of labour and cultivation they could not afford to put it closer. Where this is sown in lines, the ground is not level ; it is slightly ridged before sowing and a very high seed rate—35 lb. per acre—is used as compared to 8 lb. in the Punjab. Various reasons were given for this, the chief being that it was essential to get a good stand at all costs and that the small extra expenditure on seed was a cheap insurance. Thinning is subsequently always carried out : so that the practice would seem to be largely insurance against uneven germination.

2. The most striking thing of all regarding the cultivation is the importance laid on frequent interculture : some planters advocated running the hoe between the lines every 10 days, but the general practice was once every 12 days or fortnight ; and that is done right up to the time the plants begin to bear, *i.e.*, from March or April up to July and August ; in some cases (*e.g.*, in South Carolina) even up to September when the bottom crop has failed and a top crop is expected. If this frequent cultivation is found paying

where labour is so scarce and dear, it should have manifold advantages in India. I am more convinced than ever that the present practice of broadcast sowing and running the native plough once through the crop in the Punjab must be scrapped and in its place a method adopted which allows of organization and a prolonged system of interculture. This has been our main policy in Lyallpur for over four years and is meeting with very encouraging results.

Ridging cotton. As pointed out above, the crop is sown on a broad shallow ridge and not on the level. A similar system tried in the canal colonies had proved a failure at Lyallpur, but this summer a modification was introduced which seems to promise success. Briefly, this consists in subsequent shallow ridging after sowing and furrow irrigation. The subject is of extreme importance from the point of view of saving water and of adopting deep irrigation at less frequent intervals which seems indicated for *kharif* crops like cotton.

Picking cotton. The cotton is not picked until most of the bolls are open. Generally there are two pickings only. The average rate for picking is 80 cents per 100 lb. of *kapas*. A man can pick 300 lb. a day. In an ac ual case seen by me a carpenter and his wife and four children picked as follows:—

	lb.
Carpenter	300
Wife	200
Four children at 150 lb. each	600
	1,100

This meant an income of 8·80 dollars per day or roughly 27 rupees. In the Punjab there are as many as four to seven pickings and payment is in kind—generally 10 per cent. For picking the above amount in the Punjab payment would be 10 per cent. of 1,100 or 110 lb., and this, when Punjab American *kapas* is selling at Rs. 13 per maund, is worth nearly Rs. 18, *i.e.*, cost of picking in the Punjab is about two-thirds what it is in the States. If we take the cost per acre for say 6 maunds crop in the two countries, it would be Rs. 8 in the Punjab and Rs. 12 in the States. The relation of cost of picking in the States to total cost of raising the crop has been

generally exaggerated—*vide* Todd's *World's Cotton Crop*, page 109. Similarly the picking is much more crude in the States than in India, and the *kapas* as picked contains a lot of opened bolls and locks which, however, are separated from the cotton by the saw gins. The crop in the States remains green up to late in the season and hence in spite of careless picking very little leaf or withered bracts are found in the first pickings which constitute 80 per cent. of the crop.

Ginning. Saw gins are universal except in the Sea Island and long-staple tracts. They seem to be much more efficient than the roller gins for American cotton. One saw gin with 70 saws gets through 7 or 8 bales of cotton a day, *i.e.*, roughly 40 maunds of lint as compared to 7 to 8 maunds for the roller gins. Besides this, a better and cleaner sample is turned out and less supervision is necessary. It is said the roller gin breaks the staple in India, but they have been used in Dharwar in the south of Bombay for many years, and it is significant that up to recently this was the only tract growing American cotton. The saw gins would seem to be unsuitable for *desi* cotton as the lint is more firmly attached to the seed : hence their introduction would tend to keep American free of *desi* cotton. Other advantages offered are that with a modification of the saw gin the short staple attached to the seed could be largely recovered : this is known as "linters" and is at present fetching 4 annas a pound : at ordinary times it is worth 1 anna or more a pound and would well recoup moderate expenditure on its recovery.

Yield per acre in the States. Taking an average crop of 14 million bales of 500 lb. and an acreage of 37,000,000 acres, the average yield works out at 189 lb. as compared to 160 lb. of lint in the Punjab. The average for the Punjab has been taken as six maunds of *kapas* per acre. If we take the whole of India and take the gross crop as 6 million bales of 400 lb. and the area 25,000,000 acres, the yield works out at 96 lb. per acre for India.

Seed selection. A great deal of work is being done on this subject and very great importance is attached to selection. Crossing as a means of improvement is practically ignored. The writer was referred to Mr. Saunders of Greenville Texas as the most successful with new varieties in the Department. A variety called "Lone

Star " seemed to be in chief favour, and yet the area under it was estimated at well under 10,000 acres in spite of free distribution of seed by Congress and other methods, and even this was scattered and lost from year to year for the most part, and no record or trace of it kept. The departmental authorities could scarcely credit the fact that the Punjab Department would be handling seed for 140,000 acres direct this year. The most successful work in introducing new varieties in the States is that of Mr. D. R. Coker of Hartsville Texas, who is a private individual having no connection with the Department, though he was first attracted to the possibilities of this work by Dr. Webber ten years ago when the latter was in the Federal service. The chief reason for Mr. Coker's success is that he is a buyer of fine cotton and is able to give proper value for good staple. When the writer was with him, he saw Mr. Coker buying cotton for 15 cents and for 22 cents per lb. the same day. It is said 95 per cent. of the area under cotton in his county in S. Carolina is now producing cotton of $1\frac{3}{8}''$ to $1\frac{5}{8}''$ staple as compared to $1''$ which used to be grown there. This experience coincides with ours in the Punjab where the success of American cotton is largely due to our strenuous efforts with American cotton sales. In this connection the writer would note the following experience. While at Washington he gathered the Department were conducting investigations into the reason for differences in price in different markets on the same day. Such differences being only too common in India, the writer made a point of seeing some of these investigators in the cotton tracts. The system adopted was as follows :—The Government official had a small office in the centre in which he was working. Any farmer could have his cart of cotton graded and the staple length written down on a printed card, on condition he promised to return this card after filling in name of buyer and price realized. It transpired that every farmer practically utilized this concession and secured prices in accordance with the quality and length of his staple. The result was a marked increase in good cotton as compared to the previous year. This piece of work seemed to the writer the most significant of anything he saw in the way of cotton work carried out by the Federal Department. There is no doubt that

a chronic state of disorganization exists in the cotton markets in the States and a great deal of scientific work is simply thrown away until the economics of growing good types is taken up less academically and realized from the farmer's or planter's standpoint.

Selection in Sea Island and Long Staple Tracts. In these tracts the planters lay great stress on proper selection. The system is briefly as follows :—One plant is carefully selected after a close examination of a number of promising ones and the following year the seed of this is grown in a separate seed plot. In the second year one plant again is selected from the small seed plot and the remainder used for a larger seed plot in the third year. In the third year one plant is again selected from the smaller seed plot and the produce of the third year plot used for general sowing. Thus on every big estate there will be three seed plots, *viz.*, (1) produce of a plant, (2) increase plot, (3) increase plot. To indicate the importance attached to selection, I may quote the saying of one successful planter on James Island, Alabama, who in complaining to the writer regarding a cyclone—which had recently severely affected him—said he would not have worried over the loss of his crop but his seed plot had been destroyed and that would affect him for years. He was getting 65 cents a pound for his cotton on a regular contract when middling American was quoted at 12 cents. An adjoining farmer, whom the writer also saw, was getting 35 cents. The yield per acre in the latter case was, however, better, but not sufficient to compensate him for the lower price his produce fetched.

Cotton in Arizona (Salt River Valley) and in the Imperial Valley, California. The cotton in these places is grown under irrigation and is a new introduction in these tracts. In Arizona, Egyptian cotton of good quality was being grown, but the area under it was comparatively limited, something like 15,000 acres. In the Imperial Valley the conditions are somewhat similar to the Punjab, though the soil is heavier and richer. The methods of cultivation were very similar to those in other tracts and are described above. Water is given in abundance and the plant develops even more than on rich land in the canal colonies of the Punjab. The writer saw plots here which had given phenomenal yields on planters' estates.

In one plot which was measured, the yield had already exceeded 50 maunds of *kapas* and at least 15 or 18 maunds more could be reasonably expected. This case was the most authentic one regarding high yields that the writer came across and is remarkable. The interests of growers in this region are looked after by the Imperial Valley Long Staple Growers Association, with offices at El Centro run by Mr. A. W. Palmer, the energetic Secretary and Manager. The Association secures daily quotations and sells cotton on commission for growers.

Irrigation investigations. Though the problems of irrigation are not nearly so important or extensive in the States as they are in India, yet a great deal of investigation is being conducted on the question. The writer spent a day at Berkeley University, California, with Professor Adams, who is head of the irrigation work there, and two days at Davis where there is an irrigation experimental farm which is doing good work. A similar and better equipped station exists also at Utah, besides several smaller ones in other centres, with the main purpose of studying irrigation problems. Irrigation schemes are generally in the hands of private companies, and while water is charged for by volume, the rate is so low that little economy in the use of water seems to result. The tendency seemed to be for Government to take more and more control of matters. The problems in the States are somewhat different to those of India, but the subject is being attacked with energy and considerable outlay and in a painstaking scientific manner. It should be unnecessary to point out the moral for India.

(*To be continued.*)

EXPERIMENTS WITH NIGHT-SOIL AS MANURE.

BY

P. C. PATIL, L. AG.,

Acting Deputy Director of Agriculture, Northern Division, Bombay.

THE actual natural sources of manure which are available in Western India are at the present time very largely, if not completely, utilized. These consist of farmyard—chiefly cattle—manure, green manure obtained by burying growing crops—chiefly sunn-hemp—and in a few localities the green and dried leaves of trees ploughed in or burnt on the surface. The first of these is excellent but, largely owing to its being required for fuel, it is not available in anything like sufficient quantities. The use of green manure is extending fairly rapidly, while leaves are only available in sufficient quantities in a few localities. The use of expensive and concentrated manures like oil-cake, fish, and artificial fertilizers, has become general with irrigated crops and in intensive cultivation generally, but, so far, their profitable use has been restricted to such crops and such cultivation, and to people with sufficient resources to obtain them.

Night-soil is, however, a rich manure and is available everywhere either in the crude form or in the prepared condition as poudrette, but is hardly used owing very largely to the cultivators' scruples as to having anything to do with this material. In other highly peopled countries this is by no means the case. In Belgium it is very largely used, being carefully kept in *pucca* tanks and used as liquid manure. In Japan it is used for crops in a liquid condition, while in China its employment is all but absolutely general.

Even in Western India where it has been available in the form of poudrette and where intensive cultivation occurs in the immediate neighbourhood of a town, night-soil has gradually won its way to appreciation. At Poona, Kolhapur, Nasik, and other places where sugarcane is grown on a large scale, poudrette fetches a high price. But these cases are exceptional. In seacoast towns like Ratnagiri it has been usually thrown into the sea. In places like Broach, where no large irrigation cultivation exists, it has been burnt to prevent a nuisance. And generally it may be said that its utilization has hardly commenced in the Bombay Presidency.

In recent years, however, we have made efforts to utilize it in the neighbourhood of the smaller towns, and by experiments at the Jalgaon farm (East Khandesh) have shown its value so that the cultivators who formerly would not have anything to do with it now clamour for it at a cost of R. 1 per cartload. At Surat similar experiments have recently been made, and its use is now well known among the people. At Ratnagiri it has been used with success on rice, and at Broach and Dhulia on cotton, and an attempt is now being made to extend its use at a good many centres at least in Khandesh.

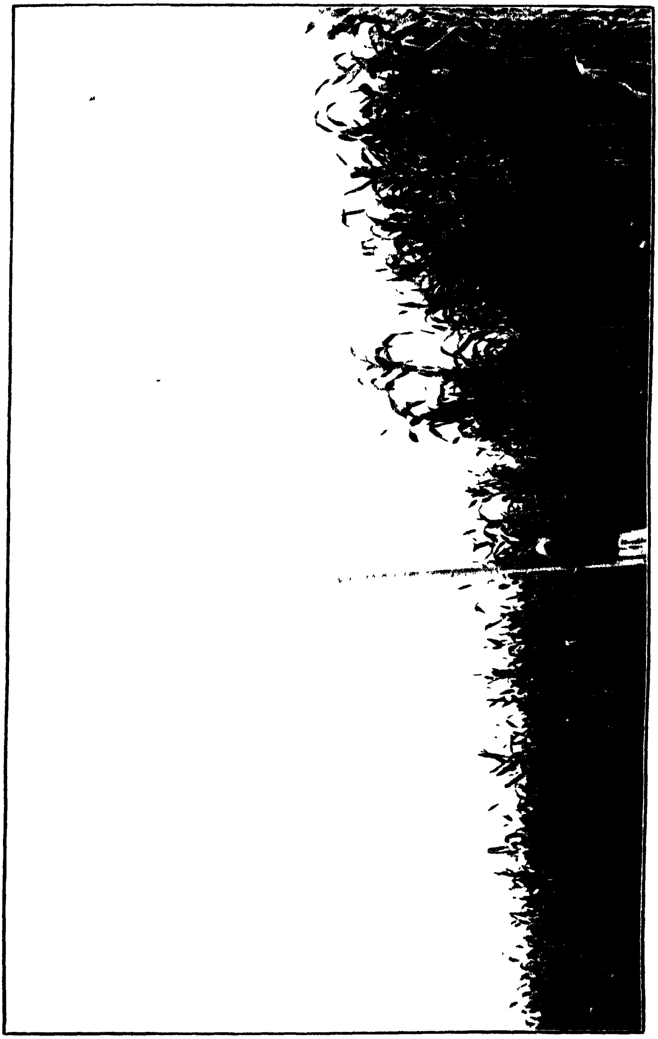
The sort of results obtainable with moderate dressings, in dry cultivation, is indicated by the following figures :—

Jowar (*Andropogon Sorghum*).—Experiment at Surat.

Dressing—40 cartloads of fresh night-soil per acre at a cost of Rs. 33.

	Yield per acre			
	Grain	Bhusa	Fodder	Total value
	lb.	lb.	lb.	Rs.
No manure .	1,055	191	1,286	59
Night-soil . . .	1,808	374	7,200	151
Increase	753	183	5,914	92

PLATE



SORGHUM Without manure.

SORGHUM Under night-soil manure.

Cotton.—

(1) Experiment at Broach.

Dressing—70 cartloads of fresh night-soil per acre at a cost of Rs. 49.

	Yield per acre	
	Seed cotton	Total value
	lb.	Rs.
No manure	264	47
Night-soil	1,108	206
Increase	844	159

(2) Experiment at Jalgaon.

Dressing— 34½ cartloads of fresh night-soil per acre at a cost of Rs. 36.

	Yield per acre	
	Seed cotton	Total value
	lb	Rs
No manure .	213	33
Night-soil	988	152
Increase . .	775	119

Rice.—Experiment at Ratnagiri.

Dressing—3,000 lb. night-soil per acre at a cost of Rs. 1-8.

	Yield per acre		
	Grain	Straw	Total value
	lb.	lb.	Rs.
No manure	2,680	2,385	105
Night-soil .. .	3,160	3,020	126
Increase	480	635	21

These results show that at present rates it is exceedingly profitable to use night-soil in the manner indicated.

It may also be noted that night-soil is a lasting manure. In an experiment carried on for the last twelve years at Surat (in the black cotton soil of Gujarat) upon a two-year rotation of cotton and *jowar*, to test the residual value of night-soil and farmyard manure, the following results were obtained. Night-soil was applied at the rate of 84½ cartloads and farmyard manure at the rate of 40 cartloads per acre in the year 1904-05 :—

Year	NIGHT-SOIL PLOTS			FARMYARD MANURE PLOTS		
	Jowar lb.	Straw lb.	Seed cotton lb.	Jowar lb.	Straw lb.	Seed cotton lb.
1904-05	2,723	7,888	... ..	2,156	6,537	.. .
*1905-06	..	.. ..	52	.....	.. ...	161
1906-07 . ..	1,220	3,964	......	931	1,876	... ..
1907-08 ...	. .	...	898	.....	.....	638
1908-09 ...	1,569	3,057	. ...	769	1,484	......
1909-10 ...	....	..	789	.. ..	. ..	465
1910-11	1,420	2,876	...	1,067	1,813	.. ..
*1911-12	.	...	51	. ....	.. .	52
1912-13 ...	588	1,635	... ..	767	1,767	.. .
1913-14	... .	.....	591	....	...	323
1914-15	992	1,961	.. ..	856	1,380	. .
1915-16 .. .	... .	. ..	991	...	......	856
Average of six years	1,418	3,562	562	1,091	2,476	416

* These were years of very deficient rainfall.

The table clearly shows the residual effects of night-soil during a long period of years. Nowadays, a smaller dose is usually given at shorter intervals.

It is true that it is rather difficult to handle this stuff in the villages. In the municipal towns where it is generally carted out it is not at all difficult, and there is no reason why every town of any size should not arrange to demonstrate its use. Our experience is that it can be applied even in the crude state without any nuisance to speak of.

The method of application is as follows :—

The plot to which the crude night-soil is to be applied is thoroughly harrowed so that a layer of three inches of loose soil is produced all over the surface soon after the previous crop is harvested. Then wide, shallow furrows are made across the field by a heavy country harrow. This is prepared in the following manner.

The space between the two prongs of the harrow is tied up with ropes passed backward and forward so as to form a sloping surface against which the earth is heaped as it accumulates. So made, the furrows should be twenty inches wide with ridges on both sides three to four inches high and one foot wide at the base. The night-soil cart is driven slowly along with its opening over the furrow and the two wheels in the adjoining furrows on each side. One full cart, containing 1,500 lb. of night-soil, has been found to be sufficient for a length of ten chains, or 330 feet, and only alternate furrows are treated. The remaining furrows are given night-soil after about three days, when the night-soil in the previous furrows gets dry, so as to allow cart wheels to roll without being soiled by night-soil. After the material has been put on, the night-soil is covered as soon as possible with the earth from the side ridges, by men working behind the cart, to prevent the breeding of flies. After two weeks the whole is quite dry, and the field is cross-furrowed with the harrow prepared as before, and again in the original direction after another week. This repeated furrowing ensures the thorough mixing of the manure. After six weeks the whole field is harrowed both lengthwise and crosswise with a heavy harrow. In addition to all this the field should also be worked with a disc harrow in both directions.

To ensure success the following conditions are required :

(1) Before application of the manure the soil should be well harrowed, at least to a depth of three inches, so that the soil to that depth is loose and soft.

(2) The rainfall should be heavy in the first two months of the rainy season.

(3) The night-soil should be applied in the dry season so that it will get dry in the soil as soon after application as possible, allowing thorough mixing with the soil, and preventing the breeding of flies.

This is the method as applicable in the case of a small town. It is, however, necessary to work out some system to use the night-soil from the villages where the majority of the people live. If this can be done, it will improve village sanitation and at the same time it will introduce an inexhaustible source of excellent manure.

The present system in the villages is no system. It is most unsatisfactory from a sanitary point of view as it spoils the surroundings of the village and often contaminates the sources of drinking water. Prejudices will die out if a better system can be worked out. The man who will find out a suitable system will do incalculable good to the villages as well as to Indian agriculture.

Selected Articles.

THE WORLD'S COTTON SHORTAGE.*

BY

PROF. JOHN A. TODD.

III. THE ANGLO-EGYPTIAN SUDAN

(Continued from page 120, Vol. XIII, Part I)

GREAT expectations have been aroused as to the possibilities of the Sudan for cotton-growing, and while there is no doubt that these expectations will in the long run be justified, it is quite another matter to say whether the Sudan may be looked to for a solution of the immediate difficulty of the world's cotton shortage. That the Sudan may quite well produce *some day* the million bales of cotton which the world requires so pressingly to-day is very likely; but the doubtful factor in the situation is time. For many reasons the development of the Sudan must be a matter of time; and time is the crux of the whole problem of the cotton supply to-day. In the first place, it must be realized that the Sudan is an enormous country with a geographical area of over a million square miles. For comparison it may be mentioned that the total area of the American cotton belt is about 700,000, and that of the British Isles about 120,000 square miles. But such comparisons are entirely misleading in another way. The cultivated area of the Sudan to-day consists of only a few relatively small strips or patches separated by enormous tracts of desert, or in the south of wild tropical vegetation like the Sudd. These waste lands of to-day are not necessarily uncultivable, but they must for a long time to come

* Reproduced from the *African World*, dated 8th September and 6th October, 1917.

lack the necessary conditions of cultivation—namely, water (except in the south), labour, and communications. This enormous country stretches from north to south through no less than seventeen degrees of latitude, and possesses a wide variety of climatic conditions from the practically rainless areas of the Red Sea littoral to the regions of tropical rainfall on the borders of Uganda and the Belgian Congo. It is thus impossible to generalize about the Sudan as a cotton-growing country. There are, for example, four entirely separate areas in which cotton is at present grown, but the conditions of these areas vary greatly in respect of climate, labour supply, and communications, which are the main factors in the development of a cotton country. Thus the bulk of the cotton actually produced in the Sudan so far comes from the Tokar District, near the Red Sea coast. There the conditions are entirely based on irrigation, for the rainfall is trifling. The water supply comes from the river Baraka, which comes down in flood once a year from the Abyssinian mountains, as the Blue Nile does into Egypt. Unfortunately, this supply is subject to no natural control; its channel varies from year to year, and the volume of the supply is unreliable. So far it has not yet been found possible to find the money for the artificial control works which would render cultivation certain over a much larger area than at present. As things are, the native cultivators cannot be expected to risk much labour or capital in preparing the land for the crop until they see whether the water is coming their way, and the effect may be summarized in the single fact that the yield of lint cotton per acre is only about 100 lb., as against an average of 400 or 500 in Egypt and in other parts of the Sudan. The largest area which has so far been under cotton in any one year was something over 50,000 *feddans* (acres), but this could be increased by about one-half if the necessary control works could be put in hand.

The labour supply in Tokar is satisfactory, being largely recruited by the migration of pilgrims from all parts of Western and Central Africa, who pass through this district on their way to Arabia for the pilgrimage, and put in a season or two here and earn enough money to carry them over the next stage.

The general character of the cotton grown is excellent. It is entirely Egyptian, and the most striking feature of the district is the way in which the Government, by careful control of the native handling of the crop at every stage from seed selection to the picking and grading of the crop, has secured and maintained a high level of quality in the product as a whole.

Another great hindrance to the development of this area is the cost of transport. The crop has to be carried on camel-back to the port of Trinkitat, from which it goes by small native boats to Suakin or Port Sudan. A railway from Tokar to Port Sudan has long been under consideration, and its construction would greatly aid the development of the district. So far the maximum crop has been that of 1914-15* *viz.*, 70,000 *kantars* (of 100 lb.), or, say, 17,500 bales of 400 lb., which, by the way, is the usual bale weight in all our African possessions outside of Egypt.

The next cotton district of importance is that of Kassala, which lies inland from Tokar on the borders of Eritrea (Italian Somaliland). Here the climatic conditions are similar to those in Tokar, the water supply being from the river Gash, another summer torrent which comes down in flood-time from the mountains, but loses itself completely in the deserts below, and as a matter of fact never reaches the Nile tributary, the Atbara, to whose basin it belongs. The greatest difficulty here is again the question of transport. At present the place is about a fortnight's journey on camel-back from the nearest station on the Port Sudan-Khartoum line, and no great development can be expected until direct railway communication is provided. This again presents no great difficulties except financial. In the meantime the record crop is under 500 bales ; but it is said that there are 120,000 acres of good land available for cotton-growing if irrigation were provided, as it could be, so that a crop of nearer 100,000 bales should be possible. It must, however, be a long time before such possibilities come within sight. The cotton grown is mostly of Egyptian quality. Coming still further inland to the Nile Valley, there are on the Nile itself, north

* 1916-17 figures are not yet available.

of Khartoum, several more or less isolated districts where cotton has already been grown with success, such as Zeidab, which lies nearly 200 miles north of Khartoum. The prospects here seemed at first excellent and very good results were obtained, but an unfortunate element of uncertainty entered into the yield owing to the danger of very cold nights during the cotton season, which may do such damage as to reduce the amount of a year's crop in a few nights from a maximum to a minimum. The result is that the crop is extremely speculative, and it is doubtful whether cotton-growing here will for some time to come be worth spending money on when there are other areas awaiting development which do not suffer from this handicap. The cost of transport by rail or river to Egypt and thence by sea to England is also a heavy handicap.

The Nile Valley areas north of Khartoum have, however, recently been entirely eclipsed by the brilliant prospects opened up for cotton development in the great plain known as the Gezira, lying between the Blue and White Niles south of Khartoum. Before the war this district had been surveyed by representatives of the British Cotton Growing Association, who brought home glowing accounts of its possibilities. There can be no question that this district, which is of enormous size, about 4,000,000 acres, or more than twice the whole acreage under cotton in Egypt before the war, will one day be a cotton-growing area of the first value. It only requires water to make it equal to Egypt in productivity, and yields of over 500 lb. an acre of good Egyptian cotton have been obtained. Before the war all arrangements had been made for its development, which meant large irrigation works on the Blue Nile, and the British Government had agreed to guarantee the interest on a loan of £3,000,000 to be raised by the Sudan Government for development purposes in this and other areas. Unfortunately, the war stopped all these schemes, and they have only recently been taken up again in a very halting way, with the result that three precious years have been lost. Perhaps, however, the time has not been altogether lost, for in the meantime the Sudan Plantations Syndicate, which is working the scheme in co-operation with the Sudan Government and the

British Cotton Growing Association, has been carrying on work on a scale which can hardly be described otherwise than experimental, but which has given excellent results. The area under cotton is now over 2,000 acres, and could be very rapidly extended if the necessary irrigation facilities were available. Transport is comparatively easy, for the main line of the Sudan Government railways runs through the district, and will carry the cotton at not too great a cost to Port Sudan; for the cotton is of Egyptian quality, and therefore of high value which will stand a relatively heavy freight.

But the great difficulty at present in the Sudan, and indeed the controlling factor in the development of the country as a whole, and of cotton-growing in particular, is the labour supply. The population of the Sudan was almost wiped out by the wars of the Mahdi and the Khalifa, and in 1898 it was said to be only about two millions as against previous estimates of over ten millions. Under the new conditions of peace and prosperity it is, of course, increasing again with Oriental rapidity; but it is still far short of the number required for the full development of the country, and for many years to come it will be a case of *festina lente*. The three years of the war have meant no check on this increase in the Sudan which has been practically out of the war, and if now the necessary development works are pushed on energetically these three years may prove to have been no real loss to the ultimate development of the country.

But this only serves to emphasize the main fact of the situation in the Sudan, which is the need of time. The Gezira will some day be one of the largest areas for the production of fine cotton in the world, but that day is still a long way ahead, and it is very difficult to guess when the Gezira crop will even touch 100,000 bales. Certainly not for some years yet, perhaps five or ten from the time when the irrigation works are completed, and these will take two or three years from the time when the money is found and the work seriously put in hand. When, then, will that be?

Finally, there are great possibilities of cotton-growing under entirely different conditions in that part of the Sudan which lies far south of the areas already described. In the Southern Sudan,

in the Valley of the Nile, there are enormous areas where the rainfall is tropical and the whole country a mass of luxuriant vegetation. Here rain-grown cotton of good quality and about American character has already been grown in considerable quantity, though the maximum crop has probably not yet exceeded 5,000 bales; and it is possible that huge areas may some day be opened up here which could supply unknown quantities of good average cotton. But that development must be in a rather distant future. The development of the Sudan will take time and enormous sums of money, and the labour supply can only increase gradually. To attempt to rush matters would be to court failure, for nothing could do more harm to the real prosperity of the Sudan than a sudden demand for labour in excess of the supply, which would artificially force wages up to a level that would render cotton-growing impossible, as it is rapidly doing in America.

To sum up, then, the Sudan is a country of unlimited possibilities for the future supply of cotton, and it may well become in the future the main source of our supply of fine cotton. But its development cannot be forced. The irrigation and other development works which the Government has already sanctioned must be pushed on with energy, and the results will certainly be such as to cover very handsomely the cost of these works and the further investment of capital which will have to be made by the pioneers of the industry.

But the cotton industry must understand that the relief which they so urgently require in the present shortage must not be expected from the Sudan within any time which they can contemplate with equanimity at the present juncture. The Sudan may in course of time make up for the shortage of the Egyptian crop; but it would be foolish to imagine that the great desideratum of a million bales of "bread-and-butter" cotton can be supplied by the Sudan, at least within the life-time of the present generation.

IV BRITISH WEST AFRICA.

In the last article it was pointed out that the Sudan may reasonably be expected to become in course of time the source of a

very large new supply of fine cotton. In the same way there is every reason to hope that West Africa will some day be able to supply a large part of the requirements of Lancashire in ordinary "bread-and-butter" cotton. But, as in the case of the Sudan, it is quite another matter to say when. As has been frequently pointed out in these articles, what the world wants to-day is a cumulative increase of about a million bales per annum of cotton round about an inch staple. West Africa is still, unfortunately, a very long way from producing that quantity, though there is no reason why she should not do so some day.

British West Africa again, like the Sudan, is an enormous country, with a total area of about 350,000 square miles, but a much larger proportion of the total area is cultivable than in the former case. Not all of it, however, could grow cotton. Along the coast is a low-lying belt of mangrove swamps of deltaic character, where cotton is out of the question. Beyond this lies the great forest belt, which, as it stands, yields so many valuable products that there can be at present little prospect of its being profitable to convert any material part of it to cotton-growing. The great cotton area is the hinterland of park-like country beyond the palm-belt, and it is estimated that, making every allowance for the amount of land that will always be required for foodstuffs, there should be an area of about 25,000,000 acres here available for cotton. A crop of five or six million bales of cotton seems, therefore, not impossible, but that is a very long way beyond the present maximum production.

In estimating the present production of the country, however, one may very easily be misled by taking merely the export figures, such as those given below from the reports of the British Cotton Growing Association. The fact is that West Africa has been a cotton-growing country for many centuries, and that the natives have all along been growing and manufacturing much of the cotton which supplies their own needs. Native cotton cloths of quite good design and character have long been produced in the district, and have established their market throughout the whole of Northern Africa as far north as the Mediterranean. It would probably be a safe estimate of the amount of this native crop to put it at

100,000 bales per annum. Herein lies the essence of the problem which the British Cotton Growing Association have had to face in West Africa, and which makes the situation there distinctly different from that of other parts of the Continent. It is not a question of teaching the natives to grow cotton. The problem is rather to show that it will pay them to grow a better variety of cotton, and export it, taking payment in the long run in goods of European manufacture. Again, there are in all parts of West Africa where cotton could be grown so many other products which compete with cotton that it is throughout a question of economics whether cotton or these other crops will pay the native producer best. The labour supply of the country is ample—the population was estimated some years ago at about 18,000,000—and well habituated to cotton-growing. But the native is, in his own way, very shrewd, and quite capable of calculating which crop will best repay him for the trouble of growing it. The Association has practically from the first gone on the lines of making the native cultivators their own masters, instead of trying to develop large European-owned plantations, with the natives as wage-paid labourers.

Under these conditions, the main factor in the problem of developing a large export crop of cotton is that of price, which again becomes largely a question of cost of transport. The price which the Association can offer to the native producer for his seed cotton—and they have very wisely always gone on the principle of offering the highest price they could afford to pay—depends on (1) the relative yield of lint cotton and seed from the seed cotton, and (2) the cost of getting the various products to market. Practically speaking, the second of these problems has been solved so far as cotton is concerned (but not seed), for the internal communications of West Africa are now, comparatively speaking, quite good. By rail and river, communication is now possible over very large parts of the country and long distances from the coast, and though, of course, an unlimited quantity of money could be spent on further development of the railways, and especially of roads in view of the possibilities of motor transport, it may be said that the lack of communications is not the worst difficulty to be solved.

The greatest difficulty now is due to the peculiar character of the indigenous types of cotton. These are, on the whole, fairly satisfactory, but they have one serious defect. The "ginning out-turn," or percentage of lint cotton obtainable from the seed cotton, is distinctly low, only about 27 per cent., as against over 30 in America and Egypt, and as high as 40 and even 50 in the case of certain varieties in India. When the Association buys the seed cotton at, say, the pre-war rate of 1⅛*d.* per lb. it is really paying over 4*d.* per lb. of lint, and when to this are added all the costs of ginning, baling, forwarding to the coast, and shipping to Liverpool, it means a cost to the Association of nearly 7*d.* per lb. of lint delivered in Liverpool. Again, owing to the cost of transport, it is almost impossible for the Association to make anything out of the seed, which, as a matter of fact, they have used to make producer gas for the power required at their ginneries. Now, if the natives could be induced to grow a better variety of cotton with a slightly higher ginning out-turn, it would enable the Association to pay them a very much higher price per lb. of seed cotton, especially if the new variety also possessed the advantage of a slightly longer staple.

It is along these lines, therefore, that the efforts of the Association have been mostly directed for many years back, and it is gratifying to know that they are apparently at last in sight of success, thanks to the untiring energy of the Director of Agriculture, Mr. P. H. Lamb, for during the last few years a new variety has been put out in Northern Nigeria, which is apparently catching hold very widely, especially in the Zaria District. For this variety the Association is able to pay 1¾*d.* per lb. instead of 1⅜*d.* for the native types, and the natives seem to find this difference quite enough to change their whole attitude to cotton-growing, especially as the new type gives a better yield per acre. During the last two years fairly large quantities of this cotton have been coming in; in 1916-17 it should have reached 2,000 bales, but a disastrous "Harmattan" reduced the yield to about 500 bales. But the seed from this should be sufficient to produce several thousand bales in the coming season. The total purchases in Northern Nigeria in 1916 established the

record figure of 10,746 bales, or more than half of the whole crop of the country. It is unfortunate that this year, owing to climatic conditions, the figures are not likely to be so good again, and this points to the chief drawback of the country as far as climate is concerned, *viz.*, the Harmattan winds. These are hot, sultry winds blowing from the interior of Africa towards the coast. They are loaded with clouds of reddish dust from the desert, and are characterized by extreme dryness. No dew falls while the Harmattan lasts, so that vegetation is withered up, and a bad spell of these winds may reduce the crop to a fraction of what it might otherwise have been. This introduces an undesirable element of uncertainty into the economic yield of the crop, and that is always very much against the struggle of cotton in competition with other crops the yield of which, though perhaps smaller, is more sure. Here, again, however, it is hoped that the new varieties may prove better able to withstand damage, so that their chances of success are still further heightened.

There seems reason to believe, therefore, that the corner has been turned in Northern Nigeria, and the development of large cotton areas there and in other parts of the country is only a question of time. Unfortunately, time is just what we cannot spare at present, and it must be realized that we cannot look to Nigeria for a large share of the desired million bales within any brief period. Five or ten years may see Nigeria thoroughly established as a serious contributor to the world's supply, but it must be remembered that the new supply will bring a new demand for cotton goods in payment. Those who wish to see the British Empire self-contained as regards its raw cotton supplies must be prepared to spend money very lavishly on countries such as West Africa, where cotton-growing is now really past the pioneer stage. The industry owes a great debt of gratitude to the British Cotton Growing Association for all that it has done to bring Nigeria through that stage, but it must not be imagined that a semi-philanthropic association with a capital of a paltry £500,000 spread over all the possible cotton-growing countries in the British Empire is a final attempt to meet the need of a large new supply of cotton. It is millions, not

thousands, that are wanted in Africa, and they are wanted to-day, not "after the war."

APPROXIMATE ESTIMATE OF COTTON GROWN IN NEW FIELDS IN WEST AFRICA, 1910—17.
(In bales of 400 lb.)

—	1910	1911	1912	1913	1914	1915	1916	1917
Gold Coast ...	100	100	120	100	100	100	100	suspended
Lagos	5,900	5,800	8,900	14,000	13,600	6,200	9,300	9,000 *
Southern Nigeria	300	300	270	200	150	100	100	100 *
Northern Nigeria .	400	600	2,600	2,000	1,000	1,200	10,800	5,000 *
TOTAL ..	6,700	6,800	11,890	16,300	14,850	7,600	20,300	14,100 *

* Estimates.

FACTORS IN AGRICULTURAL PROGRESS.*

BY

THE HON. MR. G. F. KEATINGE, C. I. E., I. C. S.,
Director of Agriculture, Bombay.

EVERY businessman knows full well that the success of any manufacturing enterprise depends on economic considerations as much as it does on technical skill. The projector of a new industrial concern will, accordingly, arrange the scope and magnitude of his enterprise in accordance with general business principles and with the peculiar economic facts of the case. The supply of raw material must be adequate and the market secure; the industry must be of sufficient size to bear the cost of efficient management, the engines large enough to supply the requisite power, the machinery efficient, the buildings properly designed, and the working capital adequate; by-products must be fully utilized, and there must be no avoidable waste of material or time. When the factory has been suitably located, designed, equipped, and financed, the primary requirements for success will have been secured, and the outcome will then depend on capable management and technical skill.

In agriculture it is, from the nature of the case, impossible that the same precision of organization can be secured as in the case of industrial enterprise; but it is certain, none the less, that success in agriculture depends largely on the factors similar to those already enumerated. Are the size and distribution of the holding suitable? Is it properly equipped and stocked? These are questions that must be answered before success or failure can be attributed to the personal characteristics and skill of the farmer.

---

* Reprinted from the *Mysore Economic Journal*, Vol. III, No. 9.

To revert to the analogy of the factory. Suppose that the directors of a cotton mill in Bombay were to call in a weaving expert to advise them as to what was wrong with their system of weaving, and the expert were to find that the mill was situated at Dadar, the offices in the Fort, and the godowns at Colaba, that the engines were much too large for the work that they had to do, the number of looms too small to turn out produce sufficient to support the cost of the management, and the working capital inadequate. In such a case the weaving expert would assuredly say, "First get all your buildings conveniently situated in one place, increase the number of your looms, and put your finances in order, and then call me in for technical advice." This is the problem that the Agricultural Department has so frequently to face when called in to advise cultivators. It is often the organization which is wrong, not the technical skill; and though there is usually ample room for improvement in the latter, many obvious improvements which might otherwise be suggested are found to be hopelessly blocked by the economic circumstances. There are many physical obstacles for the chemist, the botanist, and the engineer to surmount, but the value of their assistance must be seriously discounted where the obstacles which dominate the situation are economic; and this state of affairs must continue to exist until the economic difficulties are overcome.

By the above remarks it is not intended to suggest that agricultural salvation lies in capitalistic farming on a large scale. In some countries and in some branches of agriculture good financial results are obtained in that way; but the system of Hindu Law aims at a wide distribution of the land amongst a large proportion of the population, and the spirit of Indian agriculture indicates the peasant farmer as its ideal. With this latter view modern European opinion is in agreement, and many countries, in which the peasant farms of olden times have been merged in large estates, are now trying to call into existence a new class of peasant farmers and to revert to the old system—but with a difference; and the difference is indicated by the fact that the present aim in such countries is not merely to create peasant holdings, but to create suitably sized and

suitably situated peasant holdings, to equip them with adequate stock and capital, and to provide for their maintenance intact in that condition. It is well known how far the subdivision of holdings has been pushed in India, how large a proportion of the cultivators struggle to support life on holdings too small to provide a comfortable living by existing methods and too much fragmented to admit of such development as alone would compensate for their small size. There is no need to enlarge on the existing situation. What then would be the ideal condition? Let us suppose the plain of Gujarat or the valleys of the Deccan divided up into compact holdings of twenty to forty acres, each fitted with its homestead, cattle-shed, storehouse, and well, the houses perhaps grouped into hamlets with space sufficient to allow each man plenty of elbow room, without isolating each family in such a way as to destroy social life or render co-operative and communal action impossible, the land levelled and embanked, the holdings fenced, and each equipped with effective implements and one or more pairs of good bullocks. A distant ideal, it may be said; but still one which many countries have set before themselves and are realizing by slow degrees.

No one would attempt to force all the holdings of a country into one standard pattern. There is room and necessity for diversity and advantages in variety; but in any tract it is possible to formulate rough limits of area and equipment calculated to admit of the realization of optimum results; and it is desirable that these limits should be clearly recognized and that sustained efforts should be made to secure for a large proportion of the farmers conditions which are compatible with successful farming and effective development.

It is not proposed to discuss the method by which such change should be effected, since the question is a large one and bristles with difficulties; all that is here intended is to emphasize the primary and fundamental necessity of the agricultural situation in the Bombay Presidency. The change suggested would inevitably bring about permanent improvements now so badly needed, induce progress in agricultural practice and, by stimulating the activities of the farmers, would effect many profitable modifications in the

existing system of farming. It is, after all, the intelligent and industrious activity of the farmer which is the mainspring of production, and it is by stimulating and using to the full this agency that all improvements must be effected. The farmer has little opportunity of wasting anything, but there is one thing that he does waste lavishly—and that is his time. Once get him out of the vicious economic circle which now numbs his activities, and the results will soon be apparent.

Mention has been made of possible changes in the system of production. The thing which strikes most observers is that the Indian cultivator trusts too much to a single crop, and that he has few subsidiary sources of industry or income. With cotton at its present price the one object of the cultivator in the cotton tracts is to grow as much cotton as possible, and in this he is right; but it does not follow that twenty acres of ill-tilled and ill-manured land will give as much out-turn as ten or fifteen acres of land better tilled and better manured; and in most localities it will be found that with adequate organization the breeding and rearing of live-stock, milk production, or poultry raising offer opportunities from which most cultivators are now debarred by the existing conditions of congested villages and scattered holdings, even though the supply of fodder, the range of pasture, and the accessibility of markets may be favourable.

To turn from general economic conditions to more detailed technical questions. What are the factors in successful crop production? Soil, moisture, and temperature are the primary factors, and human effort can do nothing to affect the temperature, the rainfall, or the geological formation; but by embanking the fields and checking erosion the depth and quality of the soil may be improved, by suitable manuring and rotations its chemical and physical qualities may be modified, while irrigation and good tillage will compensate for the deficiencies of the rainfall. It is by such methods that the cultivator may become the master of his fate rather than the slave of circumstances.

Some years ago enquiries were made in Europe regarding the process of agriculture during the past century, and the relative

importance of the factors which had produced the results. Statistics show that during the past century in Europe the out-turn of wheat and other cereals has been doubled, and experts in various countries were asked to indicate the proportion of this 100 per cent. increase that could be assigned to each of the following factors, *viz* :—

(1) Improved seed.
(2) Improved and increased manures.
(3) Better rotations.
(4) Better tillage.

The experts consulted generally agreed that out-turns had increased from 50 to 100 per cent. during the past century, and in some cases it was declared that the out-turn had been trebled. The causes of this improvement were assigned as follows, *viz.* :—

	England per cent.	Germany per cent.	France per cent.
Improved seed	10	15	5 to 20
Improved manure	Considerable	50	50 to 70
Improved rotation	Little except indirect	10	...
Improved cultivation ...	Most of all	25	15 to 30

It will be noticed that manure secures the first place amongst the causes that have contributed to increased yields, and under the heading of manure is included not only artificial manure, but in an even greater measure the increased supply of farmyard manure due to the increased number of live-stock kept, and its increased value due to the concentrated foods that are now fed to cattle. Next in order comes improved cultivation, which secures the first place in England and the second place in Germany and France. It may be noted that in England, where the first place is assigned to it, the term cultivation is taken to include drainage operations. On the other hand, it is noted that in many cases where the degree of cultivation has not been improved the cost of the operations has been cheapened, and also that without good cultivation nothing like the full effects of the manure could be secured. Improved seed comes in a bad third, and it is noted that even such improvement can be secured by the use of good seed only when the cultivation and the manuring are adequate. It must be recognized, however, that the difference between the cost of using good or bad seed will amount to comparatively little per acre, and that if a

10 or 15 per cent. increase in produce can be obtained in this way there is no excuse for not securing it. Improved rotations are held to have produced little direct result, but have rendered the wasteful practice of the bare fallow unnecessary, and by adding greatly to the supply of fodder crops have enabled the farmers to keep more live-stock, and so have been the indirect cause of the increase in manure.

Now the opinions recorded above cannot, of course, be taken as a general guide in India with its varied conditions, but there are some tracts to which they would apply with a fair degree of accuracy, and they have a bearing on the question of agricultural improvement almost everywhere. In the arid tracts of India where moisture is the limiting factor in crop production, irrigation is the prime necessity, and by this means crop out-turns can be doubled and other crops of ten times the value grown. In such tracts the question of manure has little importance in the absence of irrigation : but, given irrigation, manure becomes of vital importance. Practically everywhere there is a vast field for improved tillage which is now very defective ; and wherever the rainfall is fairly abundant the supply of manure needs increasing. In the matter of seed there is certainly good scope for progress with a crop like cotton, but in the case of crops like *jowar* (*Sorghum*) and *bajri* (*Pennisetum typhoideum*) the prospects of material improvement in this direction seem to be much less hopeful. Where the land is sloping and heavy rainstorms occur, a system of field embankments which will regulate the surface water and check erosion and scouring is very necessary and produces marked results.

If an opinion were asked for as to the prospects of improvement and the methods to secure it with reference to any definite tract, it might be possible to hazard such opinions as the following, *viz.* :—

I. Improved out-turn possible on a typical sloping cotton field in the neighbourhood of Dharwar (Southern Maratha country) 100 per cent.

Factors	Per cent.
Seed	20
Cultivation	30
Field embankments	20
Manure	30

II. Improved out-turn possible on a typical cotton field in the neighbourhood of Surat (Gujarat) 60 per cent.

Factors	Per cent.
Seed	20
Cultivation	20
Manure	20

Taking the Bombay Presidency as a whole, improved cultivation stands easily first in the factors of improvement, and this connotes better implements and better cattle. The cattle are a very important consideration since they supply both the motive power for the tillage operations and the manure for the fields. Any system of farming which will enable the cultivator to breed good cattle at a profit and to maintain his work bullocks without undue cost, will do much to solve the primary difficulties of the situation, and this is very largely dependent on the organization of the land holdings, a consideration which brings us back to the point from which we started.

DEVELOPMENT OF BANKING AND THRIFT IN INDIA.*

BY

A. C. CHATTERJEE, I.C.S.,

Magistrate and Collector, United Provinces.

OF the many problems connected with India that have come to the fore during the course of the war, none is so important, and perhaps none is so complex, as the question of the economic or material development of the country. Proud as we Indians are of the share that India is taking in the great struggle, it is still a humiliation to many of us that the contribution in men and material has not been infinitely larger than we have been able to afford. It is the earnest hope of all of us that if ever in the future India is called upon to defend and conserve her liberties from external aggression, India's own effort, apart from the assistance that she will receive from the United Kingdom and other units of the Empire, will be more commensurate with her history, the immensity of her population, and the vastness of her potential wealth. In order to prepare for such a contingency, it is absolutely necessary that all possible measures should be adopted for the ordered organization of our manifold resources.

Even if we leave the problem of defence entirely out of account, there are other and urgent reasons for an immediate and sustained effort to increase the income of the people of India. Our poverty is now fully recognized. As Mr. Moreland has very clearly put it in an article in the current number of the *Quarterly Review*, "it is a

* A paper read at a meeting of the Indian Section of the Royal Society of Arts, London, on 17th May, 1917. Reprinted from the *Journal of the Society of Arts*, July 6th, 1917

matter of common knowledge that the standard of life in India is undesirably low; that, while the masses of the people are provided with the necessities of a bare existence, they are in far too many cases badly housed and badly clothed, badly doctored and badly taught, often overworked and often underfed; and that the present income of the country, even if it were equitably distributed, would not suffice to provide the population with even the most indispensable elements of a reasonable life." Our main dependence for several generations now has been on our agriculture, but the recent remarkable applications of science to the agriculture of all the older countries of the world, together with the opening out of the extensive prairies of new countries, has already threatened our position in the world market for agricultural goods, and the problem is likely to be far more acute in the near future. In industries, the revolution in processes of manufacture and organization, that has been in progress in the western world for more than a century, has wrested from us the pre-eminence in certain commodities that was ours from the early days of the Roman Empire. Our industries need development, not only to replace what has decayed, but also to supplement and reinforce our agriculture. Altogether, humanity in India has to be raised to a much higher level of efficiency and well-being than what we have so far been accustomed to.

There is one common factor in the various departments of economic development to which I have just referred. Capital is needed for all of them. It will be readily conceded that neither education nor sanitation can be developed without the laying out of immense sums of money which will not begin to yield any tangible returns for almost a generation. A more immediate remuneration is likely in other necessary directions of State activity. Means of communication and transport will absorb very large funds for a long time to come. Similarly, more money must be spent on the expansion of irrigation in tracts like Oudh, while the full exploitation of our forests can no longer be deferred without serious detriment to the national welfare. Turning to the sphere of private enterprise, capital is the primary necessity for the development of industries, and here also large or immediate returns cannot be looked for.

Additional capital is necessary for agriculture as it is for industries. A query that has often been put to me is, whether we can forecast the period of time that will be required to make our co-operative agriculturists self-dependent and self-contained with respect to capital. Frankly speaking, I cannot foresee that this condition will ever be attained. It is true that, as a result of the thrift inculcated by co-operation, the peasants will, within a measurable period of time, amass capital equal in amount to what they use now. But the capital that can be profitably utilized in their agriculture, even in the present stage of science, is almost infinitely larger than what is actually available, and we must not forget that science is progressive. It has also to be borne in mind that co-operation, while it teaches thrift, also enlightens the mind of the peasant and makes him desirous and anxious to adopt new and improved methods which involve the investment of larger capital. A year ago the number of members in agricultural credit societies in India was over seven hundred thousand, and their total capital was a little under three and a half million pounds sterling. This gives an average capital of slightly less than five pounds per member. I think it will be no exaggeration to state that, with proper training and organization, the capital required will come up to at least thirty pounds per member on the average. If the number of agriculturist families in India be reckoned as, roughly, forty millions, the funds required for financing agricultural processes alone amount to twelve hundred millions sterling. It is not possible to hazard even conjectural guesses regarding the outlay that will be needed for industrial and commercial development, or for such communal activities as education or sanitation.

It is my object to-day to draw your attention to this important aspect of the very large question of the full economic development of India. Until recently, we had a comfortable feeling that the organization of our material resources might safely proceed along lines of slow and steady growth, and that, if sufficient capital for the purpose were not readily available or forthcoming in the country itself, it could at a price be obtained from the richer and more highly developed countries of the world. The far-reaching incidence of the

war has rudely dispelled both these illusions. It is now universally realized that in the interests of India herself, and in the interests of the Empire, her economic progress should not be left to slow natural forces, and that the pace must be accelerated by well-conceived measures on the part of the State and of the people. With regard to the supply of capital from non-Indian sources, it is now abundantly clear that even if legislation does not actually prohibit, for a considerable time after the war, the export of capital from the richer countries of the world, their internal requirements will leave only a very small surplus to be shared between India and other undeveloped lands. The money that we may be able to borrow in London after the war will command a price which we cannot pay without seriously handicapping ourselves, and although I am not in a position to speak with confidence on this point, I entertain grave doubts whether we shall be able to borrow here anything approaching the amount that we shall actually need immediately after the war is over.

The conclusion is irresistible that India must in the main rely on herself and look to her own resources for the capital required for her development. To avoid any misunderstanding, I may mention that this is a view which, so far as I am aware, has never been sought to be imposed on India from without, but is only in accordance with the new ideas of true self-help that have been generated of late in our country. The question now arises: What are our available resources for the capital that is needed? The answer naturally suggests itself—India should unlock her hoards of the precious metals. From the time of Pliny she has imported large, though varying, quantities of gold and silver. In his work on "Indian Currency and Finance," Mr. J. M. Keynes states that "during the sixty years (preceding 1913) India is supposed to have absorbed, in addition to her previous accumulations, more than three hundred millions sterling of gold (apart from enormous quantities of silver)" (p. 100). Where all this gold and silver have disappeared is one of the puzzles for the economic historian of India. I do not pretend to be ready with a solution; but, apart from the partial explanation furnished by Mr. Keynes himself (p. 154), *viz.*, that "the recorded statistics of trade overland show a large balance against India, which is probably met

by an unrecorded export of gold, silver bullion and rupees," we must not forget that down to the middle of the eighteenth century India was periodically visited by bands of invaders who, in the majority of cases, left almost as speedily as they came after gathering extensive spoils in gold, precious stones, and other treasure. Also down to the beginning of the nineteenth century the pagoda tree of India was shaken for its fruit by numerous European adventurers. The costly industrial arts of India, some of which survive to the present day, must also have consumed large quantities of the precious metals. I do not deny that the gold and silver jewellery even now owned by our women will in the aggregate reach large dimensions, and I also believe that here and there individuals possess comparatively big hoards of gold and silver, while many similar and smaller hoards secreted away during the centuries of anarchy and insecurity now lie unknown to all and are permanently irrecoverable. But apart from the jewellery of the women, I am rather sceptical about the existence among the general population of any hoards of substantial value, at least in the provinces with which I am familiar. I do not wish to imply that the average peasant in India does not possess a few rupees tucked away in the roof of his hut or some other equally likely spot; and, if each person in India can be assumed to possess in the average five rupees in cash, we get the respectable sum of 100 millions sterling.

Law and order, combined with opportunities of sound and profitable investment, are, as we shall presently see, bringing to light the hidden hoards of India, and the process is likely to be considerably accelerated in the near future. Hoarding, however, as much as saving for useful employment, is a habit that takes long to instil as also to eradicate. We shall certainly be better off than we are at present when the instinct of hoarding, either in the shape of coin or bullion or in the form of jewellery, is completely overcome; but personally I do not consider that all our needs will be thereby satisfied. That is why I wish to see inaugurated as soon as possible an active and sustained campaign of national thrift through the length and breadth of the country. It is fortunate that the war loan now under flotation in India is practically originating a movement of

21

national thrift, and it is to be sincerely hoped that the organizations called into being for this immediate object will be widespread and efficient, and that they will be maintained so long as there is need for capital for the purposes of national development.

Thrift is not an unknown virtue in India, and banking in its different aspects is by no means an exotic transplanted from the West. Students of our ancient civilization are familiar with the numerous references in contemporary literature to the prevailing custom of deposits with bankers, the use of promissory notes, and the issue of letters of credit and bills of exchange for the purposes of internal and external commerce. The injunctions of Hindu law-givers on the subject of usury afford a clear indication of the practice of money-lending by the State and by private individuals. (For authorities, *vide* McCrindle's "Ancient India," p. 69; Rhys David's "Buddhist India," p. 101; Barnett's "Antiquities of India," p. 130.) References to *sahas*, or bankers, are to be noted in the early Muslim annalists. Indeed, the extensive commerce that was carried on in the Middle Ages within India itself and with countries outside would have been impossible without fairly well-developed banking facilities. In the seventeenth and eighteenth centuries the East India Company made full use of the indigenous banking agencies, and even at the present day much of the internal commerce of the country is financed by Indian bankers, though it must be admitted that joint-stock banks are fast encroaching on their domain, and their methods are not sufficiently elastic for modern requirements. It is also exceedingly doubtful whether Indian banking at any time financed industry or national development. But even in Europe the functions of banking were, until recently, strictly limited to providing for the requirements of commerce and the pressing necessities of the State. It is true that a substantial proportion of the capital used by Indian bankers has been owned by themselves, but it is equally true that they have freely received deposits from their clients and customers. A portion of such deposits is held at call and consequently free of interest, but otherwise interest has always been allowed on deposits confided with Indian bankers.

Premising, therefore, that the habit of saving for profitable employment is not contrary to the traditions of the Indian people, and that consequently there should be no insuperable difficulties in resuscitating this instinct in a more active and more widely-diffused form than in former days, we may examine the inducements for thrift that exist in India at the present moment. About six years ago Mr. Reginald Murray contributed to this Society an excellent and authoritative paper on "Banking in India," in which he furnished an account of our modern banking system. Fuller histories will be found in the standard works of Mr. Brunyate and Mr. Keynes, and in the Blue-books annually issued by the Government. I shall, therefore, refer very briefly to the types of banking that are to be met with in India. We have first of all the three Presidency Banks, which enjoy certain special privileges accorded by the Government in return for services rendered. The capital of these three banks, which stood in 1880 at £2·33 millions, had risen in 1914 to only £2·5 millions; but the reserves during the corresponding period had increased from £0·4 million to over £2·5 millions. The expansion in business has been even more remarkable. Non-public deposits, which stood at only £5·7 millions in 1880, were nearly £27 millions in 1914. The next class is that of the Exchange Banks with head offices oustside India, some transacting the greater part of their business in India, while others have merely agencies in India. It is, therefore, unnecessary to quote figures of their capital and reserves, but it is worth noting that the deposits in India increased during our period from £2·15 millions to £20 millions. We now turn to the joint-stock banks with head offices located in India. The management of several of the larger banks of this type is purely British, but I believe that a substantial portion of the capital of such banks is owned by residents of India. In 1880 there were only three joint-stock banks with a capital and reserve of over thirty thousand pounds each. In 1914 the number was seventeen, and the aggregate capital and reserves of these larger banks had risen from £0·14 million in 1880 to £2·6 millions in 1914. In the same period deposits increased from £0·4 million to £11·4 millions. As a matter of fact, in 1912 the deposits had reached the figure of £18·2 millions. The banking crisis of

1913 and the disturbance caused by the war were responsible for the decrease. In addition to these larger banks there were, in 1914, twenty-five joint-stock banks with a capital ranging between six thousand and thirty thousand pounds, which held in the aggregate £4 millions in capital and reserves and £0·84 million in deposits.

It will thus appear that in a period of thirty-four years, or roughly in the lifetime of one generation, the deposits held by the three main classes of banks have risen from £8·25 millions to nearly £59 millions. No doubt a very considerable portion of this additional capital has been contributed by British, Continental, and American merchants in business in India, but I think it will be admitted by all that the amount of purely Indian deposits has increased beyond all previous expectations.

A similar striking tale is told by the statistics of the co-operative banks. The earliest regularly constituted societies for agriculturists were established towards the end of 1904, but it was only in 1912 that a legal status was bestowed on the central banks, which attract funds from the general public for distribution among registered societies. The aggregate of the paid-up share capital and deposits from individuals in these central co-operative institutions in June 1916 was £2·2 millions. This is an achievement that cannot be pronounced anything but satisfactory, especially if it is remembered that this amount has been contributed by persons who do not expect and are not entitled to any loans. So far as these institutions are concerned, the capital available in normal times in the majority of provinces is now much in excess of the actual requirements of the movement in its present stage. Co-operative credit, if it is to take permanent root in the country, must be guided along carefully-guarded lines of development, and those responsible for the movement have wisely decided to prevent an exuberant growth at the cost of strength. Consequently deposits offered to the central banks have frequently to be refused and often returned. It has been suggested that the popularity of this class of investment is due to an idea that the Government is responsible for the solvency of these banks, but, so far as my own experience goes, there is no such general impression among the classes which actually invest in these banks.

Personally, I attribute their success to the tapping of a comparatively new stratum of depositors through the instrumentality of directors and managers who command local influence and confidence.

It is naturally impossible for an outsider to form an accurate idea of the different classes of people who nowadays deposit money in the banks in India. I had special opportunities of gathering information with regard to co-operative banks in my own province, and official duty as Registrar of Joint-Stock Companies in the province between 1912 and 1916 obliged me to examine the books of some of the smaller joint-stock banks that came to grief during that troublous period. Most of the depositors in both these classes of banks were recruited from the urban middle or professional classes. Here and there one came across the name of a landed magnate, and there were a few genuine agriculturists; and this is only what was to be expected on *à priori* grounds. In the interior of the country the industrialists and the commercial classes can, as a rule, utilize all available capital in their own business, while the natural instinct of a landholder is to invest his savings in the acquisition of more land. I am firmly convinced that the saving and investing habit can be fostered and developed to an almost infinite extent among what I have described as the urban middle or professional classes, and also under certain conditions among the landed classes.

Besides the four types of banks I have already adverted to, there are the Government savings banks run by the Post Office. They were organized in the present form in 1882, and by 1914 the number of depositors was over a million and a half, and the sum at their credit approached 16 millions sterling. The credit of the Government among the masses of India no doubt accounts for this remarkable growth; it will admit of expansion with the adoption of more elastic methods than have hitherto recommended themselves to a department of State.

In addition to these recognized types of banks, we still have in the towns and villages the two classes of individual bankers or banking families—the Seths or the big men, and the smaller money-lenders. In Bengal and in Madras new types of small corporations have been developed, known as *nidhis* and loan companies, but,

so far as I am aware, their methods are similar to those of individual bankers. Within limits, both the bigger and the smaller money-lenders invite and receive deposits from persons reposing confidence in them. Of course no figures are available. As I have said before, internal commerce is to this day very largely financed by the Seths, and the landed aristocracy usually resort to them when in need of loans. The village money-lender is still the financier of agriculture, and, in spite of the obloquy that is usually heaped upon him, continues to perform an exceedingly useful and important function in the State. Much as I dislike some of his methods, I should be sorry to see him improved out of existence at once. Perhaps my experience of the difficulties in the realization, through the processes of our civil courts, of money owed by contumacious members of credit societies, has inspired me with some sympathy for the money-lender's point of view. Legislation has been mooted to check the malpractices of money-lenders, and I hope that the remedies adopted will not be too drastic, in which case they will either remain a dead letter or seriously dislocate the entire business of agriculture. There is some danger of confusing the position and functions of the rural money-lender of India with those of the class in this country which merely exploits the vice and extravagance of foolish and ignorant people. In my view, the existing evils of usury in India will disappear with the spread of primary education among the masses and with the expansion of the co-operative movement which I trust will absorb the money-lenders among its depositors. Meanwhile, legislation is required for the registration of money-lenders, compelling them at the same time to maintain correct accounts.

I have now briefly sketched the different types of banks and bankers in India with whom deposits may be made on terms more or less advantageous to the depositor. For a person not himself engaged in industry or commerce, other means are also available for the investment of savings. The first in importance is landed property. In India, as in all old countries, ownership of land carries with it an implication of social standing and prestige, while, owing to the still surviving traces of insecure times, land is also

considered the safest form of investment. I may be accused of holding rather heterodox views on the point, but I have long been of opinion that a comparatively light assessment of the land revenue, specially in provinces where tenant-right is not strong or secure, unduly aggravates this land fever to the detriment of other and more productive forms of investment. I have in recent years frequently seen landed property purchased on the apparent basis of an annual return of less than 3 per cent., and on closer inquiry have ascertained that it was hoped to raise the actual return to 6 per cent. or higher. This state of things will probably be modified as soon as the clamant needs of local development throughout India bring about an enhancement of local taxation.

In the large commercial centres and in some provinces like Bengal, Government and semi-Government loans and other gilt-edged securities are the most popular form of investment. In Upper India they have been in lesser vogue, perhaps because there is no stock exchange or share-broker outside the Presidency towns, and securities of this type can be sold or purchased only through a bank or through the Post Office. The same difficulty affects the popularity, in the interior of the country, of good industrial securities like jute or cotton mill debentures and railway shares. Latterly, several branch or light railways have obtained in India all the capital they needed, and extensive advertisement has familiarized country investors with this form of enterprise. It is to be hoped that within a reasonable period of time respectable share and stock brokers will establish themselves in the more important commercial centres in the interior of India, and thus help forward the national thrift movement.

So far, practically all the different types of well-managed banks in India have restricted themselves to the financing of trade and commerce, that is to say, to the forms of banking business recognized as orthodox by the distinctively English tradition. I believe that European industrialists in India borrow from the banks comparatively insignificant amounts for purely industrial ventures, following in this respect the traditions of British industry. They have the advantage, in centres like Calcutta, of the "agency firms." These

firms undertake the finance as well as the superior business management of industrial ventures, and to a certain extent perform the functions of finance corporations or industrial banks. The system is not entirely free from attendant evils, but a European *entrepreneur* in touch with the presidency towns has no serious difficulty in obtaining capital for a sound proposition. Facilities of this kind are not yet available in the interior of the country, though a promising beginning has recently been made at Gwalior under the auspices of a well-known London finance house. The regular banks, whether managed by Englishmen or by Indians, cannot, in view of the proportion of capital to deposits held by them, lend to industries with any degree of safety. But even in England there is now serious questioning as to the adequacy of banking facilities for purely industrial purposes. In indigenous India, where wealth and *entrepreneur* capacity do not always go together, it has been contended that a different system, more perhaps on the models of Russia and Japan, should be adopted, and an industrial bank or banks should be organized with State aid or guarantee. The subject is too complex to be dealt with in all its bearings in the course of this paper, but it is difficult to see how the industrial development of the country, which is now so earnestly sought after by the Government as well as by the people, can be furthered without some modification of the accepted financial functions of the State. The Government of India have displayed, in the manifold risks that they have undertaken during the war, several instances of the two supreme qualities of confidence and imagination. They will be called upon in the interests of the country and the Empire to use these faculties even more after the war.

Another type of banking institution urgently needed in India is that of land mortgage banks. A few of the joint-stock banks used to do some business in land mortgage, but the recent crises have made them more cautious. It is not possible for the co-operative movement, as at present organized, to undertake the financing of large landed estates. I do not wish it to be understood that I have any sympathy with the encouragement of the landed classes in careers of vice and extravagance, but there is ample

room for the investment of money in their estates for agricultura improvements which will yield an ample return, though only in the course of a long period of time. The obstacles in the way of land banks are not so formidable as in that of industrial banks. Long-term bonds on the security of the mortgaged estates will probably prove an attractive form of investment, provided that certain technical difficulties are removed by legislation, *e.g.*, the uncertainty that usually attaches to loan transactions undertaken on behalf of a Hindu joint family or a Mussulman shareholder. The impulse in this case, as in many other forms of beneficent activity in India, has to come from the State, and it is to be hoped that the Government of India, which is now fully alive to the importance of agricultural improvements, will adopt early measures in this direction.

For some time past the question of a Central State Bank for India has been in the air. The Royal Commission on Indian Finance and Currency, which was presided over by the present Secretary of State and submitted its report a few months before the war broke out, without committing itself to any decided views on the subject, commended it as one which deserved early and careful consideration at the hands of a small expert committee in India. It seems to me that events are shaping themselves in a way that will leave the Government of India little option in the matter. For a long time to come the Government will have to rely on India itself for any loans that they may wish to raise for productive or development purposes, and a State bank will perform this function with much greater success than is at present possible. The co-operative movement is developing fast, and, as was indicated in the report of the Maclagan Committee, will soon need an apex bank for the whole of India, which will run smoothly only as a department of a State bank. If the Government commit themselves to the development of the resources of the country through State-aided industrial banks, then again a central State bank will be needed.

Whether a State bank is established or not in the near future, legislation is urgently needed to safeguard the entire movement of banking and thrift in India from unnecessary and unwholesome set-backs like what took place in 1913. The events that happened

then were foreseen by all careful observers, and it is noteworthy that in the summer of 1913, just before the panic occurred, the Government adumbrated proposals for banking legislation, and invited the expression of public opinion. Reform moves slowly in India, and the pre-occupations of the war have led to a postponement of the measure. I venture to submit that it is unsafe to leave this matter as one of the numerous after-the-war problems. At the end of the war there may be a renewed impetus for speculative, ill-managed, or dishonest enterprise. It is essential at the present critical moment that national thrift and sound banking should be encouraged by every possible means, and one of the means is to exterminate all doubtful pretenders to the name and prestige of a bank.

SALE AND LOAN OF AGRICULTURAL IMPLEMENTS.*

BY

THE HON'BLE MR. H. R. C. HAILEY, C.I.E., I.C.S.,

Director of Agriculture and Land Records, United Provinces.

THIS is not the first time that papers have been read at meetings of the Co-operative Conference on the subject of the sale and loan of agricultural implements by co-operative societies, but the course of the last few years has brought into prominence the need for certain implements, and I think it worth while dwelling on the subject again. The last three seasons have been marked by abundant rainfall extending well into October. There has been ample moisture for sowing wheat ; prices have been exceptionally good and *bhusa* has been at record prices. It might naturally, therefore, be expected that the area would have been above normal. So far from this being the case, in 1915-16 the area was about three-fourths of a million acres below that of 1914-15 ; last year it was over half a million below that figure, and this year it seems probable that there will be no great improvement over last year's figures. The reason generally given for this falling off is the difficulty experienced by the cultivators in preparing a seed bed suitable for wheat—particularly on heavier soils and in low-lying lands. As they could not break up the clods and prepare a fine tilth, they preferred to sow some other crop such as barley, the area under which has risen, or a mixed crop. The heavier soils of these provinces have

* A paper read at the Ninth United Provinces Co-operative Conference, held at Lucknow on December 18 and 19, 1917.

a tendency to run together and consolidate as a result of continuous rain, and it is this feature which makes subsequent preparation difficult. But it can be overcome with the necessary implements, and these implements are not beyond the means of the better class of cultivators, nor do they require any specially strong cattle to work them.

The ordinary cultivator has two implements, his plough and beam (*patela*). (I omit Bundelkhund, where conditions are somewhat different and where intensive cultivation is not aimed at.) The style of plough in common use is defective in many respects, though on light soils it does its work fairly well. But to obtain the desired tilth a large number of ploughings must be given, and in recent years this has been impossible. The cultivators are now grasping the fact that much better results can be obtained with the small iron ploughs, recommended by the Department, which invert and not merely grub up the surface of the soil and thus open it and clean it more thoroughly. The past three years have demonstrated their value, and there is not only a keen demand for them and an impatience at the difficulty in obtaining them, but what is more noteworthy there is a considerable sale of spare parts, showing that those already sold are appreciated. But besides these ploughs another implement is required for keeping the soils open after preliminary ploughings and to prevent consolidation during the rains. The cultivator ordinarily attempts to perform this operation, which is one of cultivating, or harrowing, and not ploughing, by means of his plough—that is, he tries to perform with a single implement what in other countries is done with several specially adapted for particular purposes. As noted above, in very light soils this can be done, but in the heavier soils containing varying proportions of clay (*matyar*) it is only possible when the season has been unusually favourable— that is neither too dry nor too wet—and such seasons can rarely be looked for. Take the case of the past three seasons. In each year there was early rain which enabled the land destined for wheat to be ploughed up before the monsoon set in heavily. Bright intervals during the monsoon permitted further ploughings ; the land broke up into heavy clods during the operation, but this did not so

much matter as they were reduced by the next rain which dissolved them and at the same time consolidated the ground. But it did matter very materially when the cultivator was able to get on the land again in the second week of October for the final preparation before sowing. The ground was then drying fast and hardening; the action of the country plough, which is not a cutting but a tearing action, was to turn up the harder soils and those on which less preparation had been impossible, in big clods; on such land the country plough neither inverts nor pulverizes the soil; it simply turns it in hard lumps. The cultivators' usual method of getting rid of these is to pass the beam over them; this, however, only pulverizes a portion of them, the largest are simply buried or dragged to the side of the field. Another ploughing at this stage with the country plough would merely have the effect of turning up again the buried clods. But with a spring-toothed harrow much of this trouble might have been avoided. In the first place, with this implement it is possible to get on the ground sooner, before it has hardened to the same extent, and, looking to the great rapidity with which the upper surface hardens, this is very important; in the second, the operation is much quicker and time is valuable; and, lastly, its action tends to break up the land—not merely tear it apart —and it is especially designed for this purpose. Further, with this implement it is possible to stir the ground more frequently during the rains; a moderate-sized field is quickly finished, whereas with a plough the operation takes some time. The ground can consequently be kept in better condition throughout the rains. The land at the Cawnpore farm is distinctly on the stiff side, yet working with this implement which ordinary oxen can draw, after ploughing with an iron plough, the land has been got ready for wheat. In some parts of the provinces a wooden roller (*lakkar*) is used to assist in getting a fine tilth, but this is not very efficient as a clod crusher, and, even when improved with blades for clod cutting, has not been found so satisfactory as the spring-toothed harrow. More commonly the cultivator is reduced to breaking up clods with a stick, and gangs of men may be seen at this work, which is a tedious and costly method. It is not therefore surprising that many cultivators preferred to put

down some inferior crop on their land, trusting to winter rains to break up the clods. Planted on imperfectly prepared land the crop is not likely to be very good, and this means that in years when we have been very much favoured in the rainfall a lot of land is under inferior crops and not yielding what it should owing to absence of proper implements for preparing it. The implement referred to, which has been found most suitable for working the soils of these provinces after a preliminary ploughing, *viz.*, a spring-toothed harrow, can ordinarily be purchased for Rs. 25 to Rs. 30, but the price has temporarily gone up considerably.

What would appear to be the best equipment for cultivating the soils of these provinces in different seasons is the small iron plough and five-tine spring-toothed harrow. Most satisfactory results have been obtained with this combination in what is a very common and profitable rotation in Oudh and the eastern districts, *viz.*, wheat after maize on *do-fasli* land. If the maize stalks are removed with the plough which cleans the land and ploughs more deeply than the country plough, and this is followed by a thoroughly good harrowing with a spring-toothed harrow, a surprisingly good tilth is obtained. It is just these parts of the provinces where there has been the biggest drop in the wheat area—the Fyzabad Division showing a drop of over a lakh of acres under wheat—and those who have seen the state of the maize land this year after it has been grubbed up—it can scarcely be termed ploughing—for a *rabi* crop, I think, would agree that the case has not been overstated. The patience and perseverance of the cultivators in trying to prepare this land are most praiseworthy, and gangs of men and women could have been seen during the past month breaking up the hard clods with sticks. But the area which can be covered in this way is comparatively small, and some of the land cannot be sown with wheat. I would recommend to owners of private farms that they try this equipment of implements themselves and then make arrangements for lending to cultivators to demonstrate their value.

Another implement the Department is trying to popularize for the western districts is the lever harrow, which is most useful in

breaking up the crust which forms on the surface after canal irrigation. This crust the better cultivators break open with their *khurpis*, but the majority, I am afraid, trust to giving another watering to break it up and provide the necessary air for the plant. The practice is not only bad agriculture but most wasteful of water, and when water in canals is scarce it means that a certain area does not get sufficient water for maturing the crop. Quite early in the eighties it was common to find attention drawn to the undesirable effects of canal irrigation on the system of cultivation, the excess of water used leading to the formation of a thick surface crust which no efforts were made to break open. Instead of attributing it to its right cause the cultivators complained of some injurious qualities of the water. A light harrow run over the soil breaks up the crust quickly and does not harm the plants. One of these harrows will suffice for a number of cultivators.

To bring these implements to the notice of the cultivators and popularize their use is primarily the work of the Agricultural Department. This we are doing by lending them to enterprising men, though at present, as I have already explained, it is difficult to procure them in large enough numbers as the price is high. Wherever the spring-toothed harrow has been lent or bought, its value is highly appreciated, and when these implements can be purchased more cheaply their use is likely to spread. But the ordinary cultivator, even if he sees these harrows at work, does not know where to procure them from and often cannot pay the whole price outright. This is where the co-operative societies can come in. The sale of implements by co-operative societies has now perforce greatly declined, but I hope that after the war it will be revived and will be carried on more systematically. Cultivators are beginning to understand that not only is their equipment of implements in many points defective, but also that with better kinds they can get the work done more cheaply and thoroughly. Heavy implements which require stronger cattle or put too much strain on the cattle in use are not likely to be widely employed; but these two harrows in the form recommended by the Department can be drawn by the cultivators' oxen. Their value, especially that of the spring-toothed harrow,

is beyond question, and if the co-operative societies arrange not only to stock them in depôts within easy reach of their members, but also sell them on the instalment system, they will be performing most valuable work for the agriculture of the provinces.

INDIA'S GREATEST INDUSTRY: SCOPE FOR AGRICULTURAL MACHINERY.*

BY

D. CLOUSTON, M.A., B.Sc.,

Offg. Director of Agriculture and Industries, Central Provinces and Berar.

THE development of labour-saving agricultural machinery is receiving much attention in England at the present time owing to the shortage of man-power due to the demands of our fighting forces. Necessity, it has been well said, is the mother of invention. English farmers conservative by nature have risen to the occasion, and thousands of self-binders, motor and steam ploughs, potato diggers, oil and steam engines for driving threshers, and other machines required for a well-equipped farm have, within the last 2½ years, been introduced in rural districts where their utility had previously been but little understood. The impetus given by war to the introduction of these new agricultural appliances is likely to become a factor of first class importance in the rural economy of Great Britain, in so far as their adoption is enabling the farmer to reduce his labour bill, to increase both his acreage out-turn and profit, and to provide more food for the nation in arms.

The encouragement now being given to the invention and manufacture of new types of agricultural machinery in the West is likely to have a very wholesome effect on the development of agriculture generally in India. For as one of our most eminent expert agriculturists has said:—" Implements for tillage are of first class importance, and this is more especially the case in India where experiments conducted by the Agricultural Department have

* Reprinted from the *Agricultural and Co-operative Gazette*, vol. XIII, no. 10.

shown the great possibilities of increasing the yield of crops by improved methods. It is almost certain, however, that this will only be brought about by improved implements as the ryot has probably reached his limits with his present stock-in-trade."

A Tenfold Increase.

The demand in India for improved implements has arisen within the last decade or so ; it is increasing every year, as may be gathered from the annual reports published by Government. It can safely be said that the number of such implements now sold is ten times as great as it was ten years ago, and that the rate of increase henceforth is likely to be progressive. This is largely due to two main causes : (1) To the new spirit abroad consequent on the active measures taken by Government to develop the agricultural resources of India ; and (2) to the growing shortage and increased cost of manual labour.

The different Provincial Departments of Agriculture have not only created this demand for improved implements by practical demonstration, but have also established depôts at which both implements and spare parts are stocked for sale. In some provinces this pioneer work has also been taken up by co-operative societies. Despite the fact that most gratifying progress has been made on these lines within the last decade, Government has as yet, however, but touched the fringe of this great agricultural problem of providing the cultivator with more efficient implements. But it has at least prepared the way for much more rapid progress, and it is hoped that, after the war, enterprising English firms will not lose the golden opportunity of establishing business connections in our Great Eastern Empire, and of thereby helping in the development of its greatest industry—agriculture.

Study Local Conditions.

To solve the problem successfully it will be necessary to study local conditions and wants of the people. The local conditions vary from province to province and even from district to district in the same province. The Gangetic alluvium of the north of India

is quite unlike the stiff clayey loam of the Deccan commonly known as black cotton soil; and a plough suited for the latter could prove too heavy for the former. There is great variety, too, in the crops to be dealt with and in the size and strength of the bullocks and buffalos which are the animals used for draught purposes. There are in parts of India good cattle the draught power of which is at least one-half that of a good Shire or Clydesdale horse at home: in other tracts where cattle are poor and neglected the average strength is very much less than that. The adoption of implements suited to the strength of various types of cattle is therefore important. In some tracts again many enterprising landowners are to be found who readily pay big prices for improved implements suited to their needs: in more backward tracts, on the other hand, the demand is for cheaper types only. But in designing agricultural implements suitable for India it should never be forgotten that both cheapness and simplicity of structure are of great importance.

The Iron Plough.

Of all the implements in common use in India perhaps none is more inefficient than the country *nagar* (plough). It may be briefly described as a piece of wood shod with an iron point which constitutes the share. It is fitted with a wooden pole and is drawn by from one to three pairs of bullocks. Having no mould board it stirs the soil without inverting it; and having no cutting parts it does not eradicate weeds. Large areas have in consequence been overrun with weeds and gone entirely out of cultivation. All the improved ploughs which have been found suitable are types designed by enterprising firms after studying local conditions. One enterprising English firm at least has, after studying the requirements of the people on the spot, turned out ploughs of types which are being sold in thousands every year. These new designs are now well known all over India. The chief advantages claimed for them are that the parts are few, simple, easily adjusted and replaced. This is important in Indian villages where expert smiths are very rarely found. In one of the best known designs, namely, the "Turnwrest" plough, the share is provided with a cutting breast

made of self-sharpening chilled material which takes the place of a coulter. This plough has proved to be admirably suited for the cultivation of black cotton soil. The salient features of this soil are that it cracks freely during the hot weather to the depth of several feet, while the thin surface soil crumbles away and forms fine powdery loose earth. Below this thin layer, the soil, containing as it does a high percentage of clay, becomes very hard and compact in the dry weather which extends from October till June, during which time the cultivation of the land has to be carried out. To plough the dry hardbaked soil with country *nagar* is a difficult task which is as a rule resorted to after a long period of years. In the intervening years the cultivator uses only his *bakhar* or blade harrow which by repeated working pares off layer after layer of soil until he gets a tilth of about four inches.

Successful Examples.

The heaviest type of Turnwrest, or Ransome's Turnwrest as it is generally called, weighs 150 lb. Its pre-war price was about Rs. 45. It can be worked by one pair of good bullocks when the soil is moist, and by two pairs when dry. There is scope for the use of even heavier ploughs than this in India ; but it must be remembered that the average holding is small, and that heavier ploughs requiring more draught would be purchased by a relatively small number of cultivators. The makers claim that the "Turnwrest" or "One Way" plough, having as it has a reversible mould board, is specially suitable for ploughing lands under irrigation, as it lays all the furrows one way and leaves the land perfectly level. Now, as a matter of fact, this particular plough has found favour only in the cotton belt where the area irrigated is quite insignificant ; so we may take it that its success is not due to the mould board being reversible. Another very serviceable plough of medium weight designed by the same firm is the "Sabul" plough, the chief characteristic of which is that the share is provided with an adjustable bar point of high grade steel. The bar is held in position by a steel wedge knocked in from the front, so that the end pressure on the bar, when the plough is at work, tends to tighten the wedge.

By loosening the wedge the bar can be moved in or out as required. The bar point is sharpened at both ends and can be reversed.

There are several excellent light ploughs made by the same firm in use in tracts where the cultivation is done during breaks in or just after the rains. These light ploughs have long poles which are fixed direct to the yoke : they are guided by a single handle or stilt after the manner of the country plough. The main frame and slade are made in one casting. The breast is of hardened steel : the share is of self-sharpening chilled material and is usually fitted with a renewable point. For medium and light ploughs one pair of bullocks only is required. It is interesting to note here that the designs of this one enterprising firm have been copied by Indian firms who are turning out roughly made, but comparatively cheap, imitations of the English-made article, without let or hindrance. The main defect in these imitations is that the share is brittle and breaks readily.

Harrows.

The use of improved ploughs must precede the use of harrows and cultivators in Indian agriculture. The soil stirred by the country plough or pared by the blade harrow (*bakhar*) to a depth of only 3 or 4 inches is not benefited to any great extent by the use of such implements as the English harrow or cultivator the main use of which is to break surface clods. Worked immediately after an English plough on the other hand, which goes to a much greater depth thereby turning up large but moist clods, the disc harrow has been found to do such good work that there is reason to believe that a demand for it is likely to arise in the near future.

Cutters and Reapers.

A fodder-cutter suited for cutting the stalks of *jowar* (*Sorghum vulgare*), of which there are many million acres grown in India, would find a ready sale. English-made fodder-cutters, designed for cutting hay and straw, are not quite strong enough to cut *jowar*, a stalk of which is ordinarily as thick as man's thumb. An American machine known as the Harder fodder-cutter has found favour in

some parts of India, but the price is much too high being about Rs. 140. An imitation of a small American hand-chopper is now made and sold in considerable numbers in the Deccan, but the amount of work done by it per day is small. In the Central Provinces several Harder fodder-cutters driven by a Hunt's small spur-wheeled bullock-gear are in use and are working well.

A reaping machine suited for cutting *jowar* would be a boon in this part of the world where the crop is at present cut down, stalk by stalk, with a small sickle. A reaper to be suited would have to be high-geared and to have a short cut of from three to four feet. The fingers of the knife bar should be strong and further apart than in a wheat reaper, and the board and prongs of the "divider" should be long so as to support the stalks which are six feet or more in length. The pole should be so adjusted that the inner of the two bullocks will not trample down the standing crop. A reaper specially designed for *jowar* is now under trial in the Central Provinces and has given satisfaction. The scarcity of harvest labour in the Punjab and comparatively large acreage yields obtained have made reapers a profitable investment on wheat lands where they can be used; but their extended use in most parts of the wheat tracts of India is under present conditions out of the question, for the reason that labour is cheap and the acreage yield so very small that the crop can be cut much more economically by hand.

THRESHING MACHINERY.

The need of improved threshing machinery for wheat is becoming more evident every year. Wheat-threshers are under trial at present and are giving promise of success. A bullock-power thresher of a suitable type should command a ready market. It is doubtful whether there is any opening for a hand-power thresher, the work of driving it being too hard for the ordinary easy-going Indian cultivator. To make the straw more edible a suitable thresher should have an attachment for chopping and bruising it, so as to break it up into short pieces as is done under the feet of the bullocks.

The primitive method in vogue in India, of treading out the corn with the muzzled ox, leaves the broken straw wheat and chaff mixed together. To separate the component parts a stronger draught is required than is usually provided by the ordinary type of grain-dresser in use in England. There are several good winnowers already on the market; many of these are Indian-made imitations of American and English winnowers which have been slightly modified to suit local conditions.

Miscellaneous Demands.

Some of the best cotton-growers in India still hand-gin their cotton (*kapas*) on a small wooden country mill. Worked by one person, the average quantity of *kapas* dealt with per day does not exceed 25 lb. A hand-gin capable of dealing with not less than 100 lb. of *kapas* a day would find a ready sale. In the absence of such a machine there has been a demand in the cotton tract of the Central Provinces for small ginning plants, each consisting of from two to four gins driven by an oil-engine.

In cane-growing tracts good bullock-driven cane mills find a ready sale. Light three-roller mills that can be worked by one pair of bullocks are most in favour. A certain number of small power cane-crushing mills has been set up in Bombay and Southern India, which are said to be giving great satisfaction. The small amount of work done by the bullock-driven mills in use at present is undoubtedly one of the greatest difficulties in the way of extending the area under this crop. The introduction of a small and efficient power plant, capable of crushing about 10 tons of cane per day, would be an enormous boon in cane tracts.

There is already a considerable demand for water-lifts, dairy appliances, and fencing material: there would be a demand, too, for a good retting machine suitable for retting the common fibre crops grown, but such a machine has yet to be designed.

How to Proceed.

To get into touch with the Indian market a British firm intending to do business in India should get the assistance of the

Agricultural Adviser to the Government of India and of the Directors of the Provincial Departments of Agriculture. The Director of a province, with his staff of agricultural experts and agricultural engineer, is in a very good position to say what the requirements of the cultivators are. He is always able and willing, too, to encourage the introduction of approved agricultural implements and machinery through official agencies. To start a successful business capable of great expansion it would be advisable for the firm to manufacture the bulk of its implements in India under the supervision of its own engineer whose duty it would be to design types to suit varying local conditions, in the light of knowledge gained on the spot and of the advice which would be willingly given by the Government.

Once established it would be necessary to advertise freely and to publish descriptive articles in the more widely read agricultural publications such as *The Agricultural Journal of India*. An article published in the April number of that *Journal* in 1913 (Vol. VIII, Part II) setting forth the merits of woven pigproof wire-fencing, but little known in India at that time, gave rise to quite a demand for that type of fence. I could quote many other instances to prove that in India there is a potential demand for improved agricultural appliances, but that judicious advertisement is necessary to bring their merits to the notice of the Indian landholders.

A FEW SIMPLE TESTS FOR USE OF DAIRY FARMERS, DAIRYMEN, AND STUDENTS.*

BY

R. OSBORNE, N. D. D. (I.)

In compiling this article the writer is not breaking new ground, as details of all the tests have already been published but are scattered through various works, and it is with the object of rendering them readily accessible that they are now being reproduced.

Some of the tests are very well known but are here mentioned in order to make the list as complete as possible.

Milk Testing.

The Gerber Test. This is a cheap and simple device for determining the percentage of fat in milk, cream, buttermilk, and separated milk, and will be described first.

The articles necessary are :—

(*a*) A centrifuge (known as Gerber's Butyrometer).

(*b*) Milk pipette holding 11 c.c. ..		Supplied with machine.
(*c*) Acid ,, ,, 10 ,, ..		
(*d*) Alcohol ,, ,, 1 ,, ..		
(*e*) Special test bottles ..		
(*f*) Stoppers for test bottles ..		
(*g*) Stand for test bottles ..		

(*h*) Sulphuric acid of a specific gravity of 1·825.

(*i*) Amylic alcohol ,, ,, ,, ,, 0·875.

---

* Reprinted from the *Journal of Dairying and Dairy Farming in India*, vol. IV, part II.

Where again referred to in this article the whole of the above will be described as "Gerber's Test."

There are several special measures to facilitate and render safe the measuring of the acid and alcohol, but it is beyond the scope of the present article to describe them.

1. *To test fresh milk.*

Place the test bottles mouth uppermost in the stand.

Draw 10 c.c. of acid into the pipette which should be provided with a safety bulb to prevent the acid reaching the mouth, and place the forefinger over the end of the pipette (a plug of cotton-wool may be placed in the mouthpiece if desired for additional safety). Allow the acid to run into the test bottle, taking care that the neck of the bottle is kept dry.

It is unnecessary to blow the last drop out of a pipette.

Similarly measure 11 c.c. of milk and add to the test bottle. Great care must be taken to avoid violent contact between the acid and milk. It is best to allow the milk to run gently down the side of the bottle.

Now add 1 c.c. of amylic alcohol.

It is essential that all liquids should be carefully and accurately measured.

The neck of the bottle must be kept dry, or there is a risk of the rubber stopper flying out.

The test bottle should now be corked with the rubber stopper which should be well pushed home.

Invert and shake the bottle until all the casein has been dissolved by the action of the acid. The mixing of the milk and acid causes a rapid rise of temperature, and it is advisable to hold a bottle with a cloth while shaking.

The bottle should now be placed in the centrifuge with the stoppered end outwards, and revolved for three minutes.

On removing the bottle, the fat will be found collected in a clear column at the thinner end of the bottle.

The column of fat, if not already there, must be brought on to the graduated scale.

This may be done by either pushing in or slightly withdrawing the stopper. It may be pointed out, however, that it is far better to arrange the position of the stopper *before* the bottle is put into the centrifuge instead of after rotating.

Get the lower end of the column of fat level with one of the long graduations on the scale, and it is then a simple matter to read the result. Each long division of the scale is equal to 1 per cent. of fat in the sample, and each short line is equal to 0·1 per cent.

Greater accuracy is ensured if a pair of dividers is used for measuring the column of fat, to avoid having to raise or lower the column, as in the latter case a thin film of fat remains adhering to the glass and slight errors result.

It will be observed that the upper end of the column of fat has a curved surface called the "Meniscus." The reading should be taken to the bottom of the Meniscus.

Note. It is important that the sample of milk should be thoroughly mixed immediately before testing. This can be done by pouring from one vessel into another several times

2. *Testing separated milk.*

The process of testing separated milk is the same as for whole milk, except that a special test bottle with a tapered scale known as the "Precision" test bottle is recommended as giving greater accuracy. It is also necessary to remove the bottles from centrifuge after rotating for three minutes and place them in a water bath at about 170°F., rotate for another three minutes, again place in the bath, and finally rotate for one minute.

This ensures the complete separation of the fat. Results should be read in this and all cases when the contents of the test bottles are at a temperature of not less than 140°F.

3. *Testing buttermilk.*

This is done in the same way as separated milk.

The chief difficulty is to obtain a correct sample. The amount of breaking water added to the churn should be noted.

The whole of the buttermilk should be drawn off and weighed, and a sample taken.

The quantity of breaking water should then be taken into consideration when reading the test, and the correct reading calculated.

4. *Testing partly churned milk.*

When milk has been partly churned, heat the sample in a hot water bath until the fat is melted, then thoroughly shake the sample until the whole is a perfect emulsion, and test immediately in the normal way.

5. *Testing frozen milk.*

When milk freezes the outer portion of the milk has a very low fat content, and the milk must be thoroughly thawed and well mixed before testing.

6. *Testing sour milk.*

When milk has curdled the curd may be broken up by the addition of ammonia. Take some ammonia and dilute it to the proportion of one part of ammonia to four parts of water. Add 5 c.c. of this to 100 c.c. of milk. Shake gently until all the casein is dissolved. Test this mixture in the ordinary way.

The fat reading must then be increased by $\frac{1}{20}$th to allow for the ammonia added, *i.e.*, if the fat reading is 6 per cent. the correct reading would be 6 plus $\frac{1}{20}$ of $6 = 6{\cdot}3$ per cent.

THE LACTOMETER.

The lactometer is an instrument which registers the specific gravity of milk. It is often advertised as an instrument which will test milk. This is incorrect, but it is frequently desirable to know the specific gravity of a given sample of milk in order to calculate the total solids.

The lactometer requires very careful handling to ensure correct results.

It must be kept scrupulously clean, as a little dust is sufficient to impair its accuracy while if it is put away after use without careful washing the next reading is certain to be inaccurate.

The lower part of the lactometer is a weighted bulb, and the upper part a stem or rod with a scale marked thereon.

Lower the bulb slowly and carefully into the milk, which, as usual, must be well mixed previously. Care must be taken that no part of the instrument touches the vessel, and it is an advantage if the eye can be brought on a level with the surface of the milk to ensure correct reading.

If froth is present it must be removed. Observe the figure at the surface of the milk, and this will indicate the specific gravity of the sample.

For the sake of uniformity, the lactometer is made to register the specific gravity of milk at 60°F., as the density of liquid varies with the temperature.

This point is important, but often overlooked. It is best to have the milk as near 60°F. as possible, but variations from this temperature can be allowed for as follows :—

For every degree of temperature above 60°F. add 0·1 to lactometer reading, and for every degree below 60°F. deduct 0·1 from the lactometer reading.

This correction may also be rapidly made with the aid of a Richmond Scale, which will be described later.

The specific gravity of genuine milk varies with different samples, dependent upon breed of animals, period of lactation, individual characteristics, and many other factors.

It may be said to range between 1·028 and 1·034 at 60°F., but there are exceptions even to these wide variations.

Fats reduce the specific gravity, being lighter than water.

Other solids increase the specific gravity, as they are heavier than water.

It is evident, then, that the use of the lactometer is limited. It is only of practical use when combined with an apparatus for testing the amount of butter fat present.

Estimation of Total Solids.

To estimate the total solids in milk, it is necessary to know (1) the percentage of fat present, which can be ascertained by the

Gerber Tester; and (2) the specific gravity at 60°F. as indicated by the lactometer.

With these data, the total solids can be calculated by the following formula :—

$$\left.\begin{array}{c}\text{Total}\\ \text{solids}\end{array}\right\} = \frac{\text{Specific gravity}}{4} + \frac{(\text{Fats} \times 6)}{5} + 0{\cdot}14$$

This calculation is much simplified by the use of the "Richmond Milk Scale."

The scale is constructed with a twofold object. The necessary correction of the lactometer reading, when the temperature of the sample is not exactly 60°F., may be immediately ascertained, and the percentage of total solids rapidly calculated.

The scale is constructed with a sliding slip in the centre and is used as follows :—

Use of Richmond's Scale to obtain corrected specific gravity.

At the top of the scale to the left will be found a scale marked "Temperature."

On the top edge of the movable centre slip will be found a scale marked "Lactometer Readings," ranging from 22 to 37.

To obtain the corrected specific gravity, place the lactometer reading obtained opposite the line marked 60°F. on the temperature scale and the corrected specific gravity will be found opposite the temperature at which the lactometer reading was taken. For example, if the actual reading was 32 at 65°F. place 32 opposite 60°F., then in line with 65°F. will be found 32·65 which is the corrrected specific gravity.

To find total solids.

Now that the percentage of fat and the correct specific gravity are known, the total solids may be found as follows :—

On the right top side of the scale is a scale of fat percentages.

On the right top of the sliding centre piece will be found an arrow.

On the bottom edge of the sliding piece is a scale of specific gravities.

Along the bottom of the scale is a scale marked "Total Solids."

Place the arrow opposite the line showing the percentage of fat present in the sample.

Find the corrected specific gravity on the lower edge of sliding scale.

The line of the specific gravity will correspond with the total solids on bottom of scale.

For example, suppose a sample of milk has a fat percentage of 3·5, and a lactometer reading 32·65, then, by placing the arrow against 3·5 on the scale marked "Fats," it will be seen that the specific gravity 32·65 is in line with 12·55 on the total solid scale. Thus 12·55 per cent. represents the total solids in the sample.

It will be noticed that the scale will only calculate milk with fats less than 6 per cent.

Buffalo's milk is usually higher in fats than this, but the solids may be calculated by dilution of sample with an equal quantity of water, and then multiplying all results by 2.

OTHER MILK TESTS.

Artificial colour in milk.

To test for artificial colouring matter in milk, which is sometimes added to give the milk a fictitious appearance of richness, take 10 c.c. of milk and add an equal quantity of ether. Shake well and then stand until ether rises to the surface.

If the milk is uncoloured the ether solution will be colourless; but if colouring matter is present the ether solution will be coloured.

The intensity of the colouring will give an idea of the amount of colour added.

Controls of milk known to be uncoloured should be prepared for comparison.

DETECTION OF PRESERVATIVES.

The commonest preservatives used in milk and milk products in India are boric acid and other boron compounds, and formalin or formaldehyde. These are active poisons, and their use even in very minute quantities should be discouraged, and it is considered that their presence should always be declared. When it is

remembered that large quantities of milk are consumed by infants the importance of the subject can be realized.

Boric Acid or Borax.

To detect the presence of these preservatives proceed as follows :—

"Take a small quantity of the suspected milk (15 c.c. is a handy quantity). Add a few drops of phenol-phthalein, and then allow diluted caustic soda to drop in until the milk acquires a delicate pink tinge.

"Now add an equal quantity of a mixture made up of equal parts of glycerine and water.

"If borax or boric acid is present the pink colour disappears, but if no preservative is present no change occurs."

Formalin or Formaldehyde.

To detect the presence of this preservative pour some strong sulphuric acid into an ordinary test tube. Dilute a small quantity of milk with an equal volume of water, and run the mixture into the test tube, allowing it to run down the side.

Watch the line of junction between the two liquids. If formalin is present a violet ring is formed. If no formalin is present a greenish colour appears which quickly changes to brown.

The colour is more pronounced if a few drops of ferric chloride are added before the acid.

A Rapid Test for Acidity of Milk.

In creameries, where milk is pasteurized before separation, it is often desirable to know whether milk will stand the pasteurizing temperature without curdling. It has been found that milk with an acidity of more than 0·2 per cent. cannot be satisfactorily pasteurized.

Take 10 c.c. of the doubtful milk, add three or four drops of phenol-phthalein, and then add 2 c.c. of caustic soda solution.

(The preparation of this solution is described under the head of "Test for Acidity of Cream.")

If the milk remains white it is unsafe to attempt to pasteurize, and it should be separated unheated.

If the sample turns pink it contains less than 0·2 per cent. of acid and will stand the pasteurizing heat.

* * * * * * * * * *

It is desirable now to refer briefly to the advantages which accrue to dairy farmers and others through being able to carry out simple and inexpensive tests of dairy produce.

That advantages exist none will dispute, but it is intended to indicate some of the more important ways in which testing may be put to good account :—

1. Milk testing enables a farmer to detect unprofitable animals, more particularly when it is his aim to produce butter-fat.
2. It has made possible the purchase of milk according to quality. This has made the modern creamery practicable.
3. Adulteration may be detected and checked.

The only class of person to whom this is not an unmixed blessing is the dishonest milk vendor.

In this connection it may be pointed out how different classes of adulteration will be indicated. It is unfortunately far more difficult to detect and check adulteration in India than it is in countries where dairying is in a more up-to-date condition.

The principal causes of this are :—

(*a*) There are no universal regulations in India controlling the sale of milk, and in consequence adulteration is very widespread.

(*b*) The milk of cows and buffalos is sold either separately or mixed, and the composition of milk is very variable even when genuine.

(*c*) There is very little information available as to the average composition of genuine milk in India, which is however far richer than in Europe and America.

(*d*) The production of milk is generally in the hands of illiterate and dishonest dealers.

As before mentioned, the existing information relating to the composition of Indian milk is meagre, but the following are figures obtained by investigators at Poona when testing a fairly large herd and may be accepted as reliable. The testing was carried out by means of the Gerber Tester, the Lactometer, and Richmond's Formula :—

	Water	Fats	Proteids	Sugar	Ash
Buffalo's milk ...	81·1 to 82·2	7·6 to 8·7	4·2 to 4·3	4·7 to 5·2	0·8
	Solids not fat ...		9·9 to 10·4		
	Total solids ...		17·7 to 18·8		

Specific Gravity at 60°F. 1·031 to 1·0315.

	Water	Fats	Proteids	Sugar	Ash
Cow's milk ...	84·9 to 85·8	5·3 to 5·8	3·5 to 3·8	4·4 to 4·9	0·7
	Solids not fat ...		8 8 to 9·3		
	Total solids ...		14·2 to 15·1		

Specific Gravity at 60°F. 1·029 to 1·030.

It must be borne in mind that the above figures make no pretence at showing extremes in exceptional animals, but are intended to show the class of milk an average herd should produce.

When the quality of a sample of milk is suspected, first determine the percentage of fat, then find its specific gravity, and calculate solids not fat and total solids.

In drawing conclusions relating to suspected adulteration remember that—

(*a*) fat is lighter than water,
(*b*) milk is heavier than water,
(*c*) skimming increases the lactometer reading,
(*d*) skimming decreases fats and total solids, but does not materially alter the solids not fat,
(*e*) watering decreases fats and total solids,
(*f*) skimming and watering may give a normal lactometer reading.

The following table of examples is appended to show the conclusions which may be arrived at in dealing with suspected milk from a herd of cows :—

	A	B	C	D
Fats	5·5	3·9	4·2	4·0
Solids not fat	9·0	8·8	9·0	8·0
Total solids .	14·5	12·7	13·2	12·0
Lactometer reading ...	1·030	1·030	1·032	1·027

A is considered to be a genuine sample ; B is probably watered and skimmed because fats are low, lactometer reading is normal, and total solids low ; C is probably skimmed because lactometer reading is high and fat is low, solids not fat being normal ; D is probably watered because everything is below normal.

Cream Testing.

There are two tests of cream which are of importance to the butter maker.

The first is to test the cream for butter fat and the second for acidity.

The butter fat test assists the butter maker to accurately calculate the overrun and thus eliminate losses.

The acidity helps to ensure a uniform quality and flavour of butter and also promotes exhaustive and complete churning. In both these objects the butter maker is also assisted by the tests for fat in butter milk and water in butter, both of which are mentioned elsewhere in this article.

Testing for Fat in Cream.

Measure 11 c.c. of cream with a milk pipette and pour into a small vessel. Then take 6 or 7 pipettes of water, and thoroughly mix with the cream, making sure that all the cream is washed out of the pipette. Test this mixture by the Gerber method in the same way as milk. Multiply the result by the total number of pipettes used, that is, if 6 pipettes of water were added, multiply by 7. The object of the dilution is to bring the reading within the scope of the ordinary test bottle.

Many writers advocate the weighment of cream instead of measurement, as ensuring great accuracy, and it is an undoubted

fact that the specific gravity of cream decreases as the percentage of fat increases : so a distinct possibility of error is introduced by the measurement instead of weighment.

When the pipette system of dilution is carried out a small correction is necessary.

This correction is shown in the following table :—

Per cent. fat found	Correction to be added	Per cent. fat found	Correction to be added
20	0·12	....	.....
21	0·16	36	0·83
22	0·19	37	0·90
23	0·23	38	0·96
24	0·26	39	1·03
25	0·30	40	1·09
26	0·34	41	1·17
27	0·38	42	1·24
28	0·42	43	1·32
29	0·45	44	1·40
30	0·48	45	1·48
31	0·54	46	1·56
32	0·60	47	1·64
33	0·66	48	1·72
34	0·72	49	1·80
35	0·77	50	1·89

If the dilution method by weighment is desired, carefully weigh 10 grammes of cream.

Then measure 60 or 70 cubic centimetres of water and proceed as above described.

This method greatly reduces the margin of error as the water can be measured in bulk in a burette instead of with a pipette, while the weighment of cream eliminates the error due to varying specific gravities.

In carrying out this test the following sources of error should be avoided :—(1) Sour cream ; (2) use of wet pipettes or flasks when first measuring out the cream ; (3) careless mixing, whereby air bubbles are drawn into the pipette along with the cream ; (4) drawing the cream too far above the mark in the pipette ; (5) loss of fat when adding water for dilution ; (6) imperfect mixing of the diluted cream ; (7) fine particles of fat left on the pipette when the diluted cream is run into the test bottle ; (8) reading the results at too low or too high a temperature.

TEST FOR ACIDITY IN CREAM.

The principle of this test is as follows :—

A few drops of phenol-phthalein are added to the cream to be tested.

This substance is colourless in the presence of an acid, but turns pink in the presence of an alkali. The change of colour indicates the point when all the acid has been neutralized and the liquid becomes alkaline. The degree of acidity is found by using an alkali of known strength and noting how much alkali is necessary to neutralize the acid in the sample. Caustic soda is the most common alkali used.

Apparatus required. (*a*) A burette for measuring the caustic soda solution graduated in cubic centimetres and tenths of cubic centimetre. (*b*) Caustic soda solution (prepared by dissolving 4·5 grammes of 98 per cent. pure caustic soda with one litre of distilled water). (*c*) Phenol-phthalein. (*d*) Pipette holding 10 cubic centimetres. (*e*) Small porcelain dish. (*f*) Glass rod for stirring.

Method. Accurately measure 10 c.c. of cream, add three or four drops of phenol-phthalein. Note quantity of caustic soda solution in the burette.

Allow the caustic soda solution to fall from the burette drop by drop into the sample. Close watch must be kept and the sample stirred. When a permanent pink tinge is apparent, the addition of the soda solution must at once stop.

Read from the burette the number of c.c. of soda solution used.

In this method 1 c.c. of caustic soda solution used indicates that 0·1 per cent. of acid has been neutralized, and the calculation of the result is therefore simplicity itself.

For example, if 4 c.c. of solution are used, it indicates that 0·4 per cent. of acid was present in the original sample, or if 5·5 c.c. are used the acidity of the sample was 0·55 per cent.

TO ASCERTAIN PERCENTAGE OF WATER IN BUTTER.

For this purpose a special apparatus known as the Sorensen's Tester is recommended.

The maker's instructions for the use of the apparatus are as follows :—

A small portion, weighing not less than 10 grammes of the butter to be tested, should be placed in one of the empty bottles provided with the apparatus and the stopper put on. Melt the butter by standing the bottle in hot water, about 140°F.

Place the metal dish with the glass stirrer in it upon the balance; adjust the screw at the end of the arm at the balance, so that the weight of the dish and the glass rod is exactly balanced.

Remove the dish from the balance and pour into it about 9 to 10 grammes of melted butter; shake the bottle immediately before pouring out the butter to ensure obtaining a uniform sample.

Replace the dish with the stirrer and the butter in it upon the balance and weigh it by means of the movable weights placed upon the lever. These weights are of three sizes, the largest represents 1 gramme, the next size 0·1 gramme, and the smallest 0·01 gramme. For example : If the largest be in the notch marked 8, the second size in the notch marked 6, and the smallest in the notch marked 4, the weight of the butter will be 8·64 grammes.

Remove the dish with the butter and the glass rod on to the tripod and heat it by means of the spirit lamp stirring it in the meanwhile until all the water has evaporated. When the butter has ceased to foam the dish is removed and set aside to cool.

After cooling, weigh it again, including the glass rod, and deduct the second weight from the first, which will give you the amount of water which was contained in the sample and from which you may easily calculate, according to the following form, the percentage of water which it contains.

For example :—

Original weight of butter	9·60	grammes.
Weight of butter after heating	8·50	"
Weight of moisture	1·10	grammes.

$1·10 \times 100 \div 9·60 = 11·46.$

The butter contained 11·46 per cent. of moisture.

An ordinary chemical balance may be used for this purpose with similar dishes and rods, but the process is more lengthy and troublesome.

Notes.

ACACIA MODESTA, A HEDGE PLANT.

THE photographs reproduced (Plate XX) may be of interest to those who are trying to grow hedges or testing plants with that object in India. The plant is *Acacia modesta*, not indigenous to Burma, but, I think, to the greater part of North-Western India. It produces a very thick, impenetrable hedge in a short time and is here (Mandalay) far superior to any of the other plants, *e.g.*, *Inga dulcis*, *Acacia arabica*, *Duranta*, etc., that have been tried.

Acacia modesta if properly treated does not, like *Inga dulcis* and some other plants, grow tall and form a top without any thickness below. It is impenetrable to the ground and at two years old the hedge shown in the photographs was quite impassable even for a hare. Moreover, this plant does not require so much cutting as some others, like *Acacia arabica*, which send out strong shoots so freely that it is difficult to keep them within bounds without continual clipping. Two (or at most three) clippings are given annually to the hedge shown. The spines of *A. modesta* are plentiful but not so long as those of *Acacia arabica*.

This hedge is growing on a stiff, impervious clay where trees and few plants can be grown without the greatest difficulty, yet at two and a half years old it was about 4 feet high, the desired height, and so thick that no stock, not even a buffalo, would try to pass through it. It has since gradually thickened and at seven years old is still thriving, and to all appearances will continue for several years more before it needs cutting down. It withstands the extreme dry weather, except when very young (the first year) without water though it loses some of its leaves at that time if not watered. Even then owing to the free branching it is not possible to see through the hedge.

We have so far been able to grow it from seed only—cuttings do not "take." The seed should be sown as soon after it is ripe as possible, *i.e.*, about September-October.

On this waterlogged soil we sow on a slight ridge in a single line about one seed to the inch and cover with ½ to 1 inch of soil. On more genial soil less trouble should be required. If rains are unfavourable watering is necessary till the following monsoon. Judicious clipping when the plants are young will induce free branching and easily give density below. The hedge should of course be allowed to attain the required height and thickness by slow degrees—each clipping permitting it to grow a little larger. If this is not carefully attended to density is lost. If cut down almost to the ground *Acacia modesta* will shoot again freely, so that it should not be difficult to renovate an old hedge.

When clipped into the form of a hedge the plant seldom produces any seed and the supply of this for further sowing is a great difficulty here, for there is a lively demand which we are entirely unable to meet. Seed obtained from the Punjab did not germinate—partly because it was badly damaged by larvæ of some insect, but largely, we believe, because it was old and had lost its vitality. We shall therefore be greatly obliged if any reader of these lines in India can help us in obtaining fresh seed.

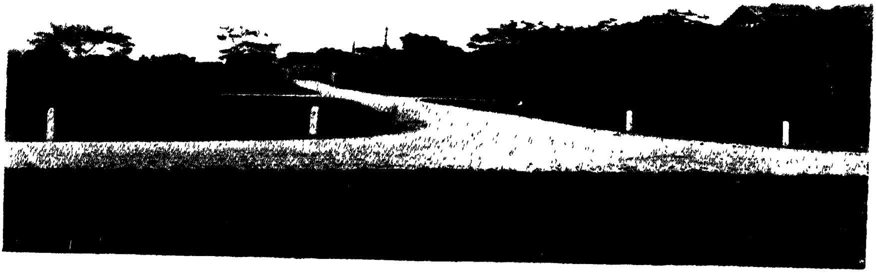
This plant, the merits of which were discovered by accident, is strongly commended to the notice of those who wish to grow useful and at the same time ornamental hedges.—[E. THOMPSTONE.]

***

WITH regard to **bee-keeping**, the following note by Mr. W. P. Thompson, Executive Engineer, Public Works Department, Irrigation Branch, Hafizabad Division, Lyallpur, will be read with interest :—

I had often read with interest of bee-keeping as a cottage industry when a coincidence made me a bee-keeper's neighbour for a period of four weeks during leave taken in the summer of 1915.

Bad fortune took me to the Seychelles and good fortune made the bee-keeper my neighbour. This enterprising man had imported



Typical Hedges of *Acacia modesta*.

fertile Italian queen bees from Italy by post and had succeeded, when I met him, in establishing an apiary of some twenty colonies, and much honey did we consume during these weeks. It was purchased at the interesting price of four annas for a frame containing a pound and a half of honey.

On my departure from the Seychelles I purchased two queens at Rs. 3 each, but, owing to my ignorance of the habits of my royal captives, they perished from cold before I reached my destination, and my effort at introducing these active workers into another corner of the Empire failed entirely.

On my return from leave a notice in the *Pioneer* brought to my knowledge the existence of the Simla Bee-keepers' Association, and the publication on bee-keeping by the Pusa Institute.

I had a hive made and even captured several swarms of *Apis florea* which, however, are not domestic and would not accept the hospitality of my hive in spite of proffered syrup.

A fortunate coincidence in the summer of 1917 made me the neighbour of Mr. Cousins at Kasauli, and with his courteous assistance I have been able to start experimentally with bee-keeping at Lyallpur, and the inauguration of this colony in its new surroundings I proceed to tell about.

During the winter months of 1915 and 1916 I had noticed in my compound and neighbouring ones several colonies of *Apis florea*, and this was certainly an indication that congenial pasturage was available. Having secured the necessary implements I brought down a swarm of *Apis indica* from Kasauli, starting on the 7th of October and having them at Lyallpur on the 10th.

The weather was propitious and the bees accepted their new surroundings and brought in from the *kikar* (*Acacia arabica*) trees and the *toria* (*Brassica Napus*) crop, then in bloom, all that they required.

By the 3rd of December they had got on so well that they swarmed. This swarm was captured on the 4th and hived. Successive swarms issued on the 11th and 12th.

The third swarm, which I was able to capture on the day of issue, I united with the first swarm.

The fortunes of the second swarm are worth relating.

I captured them on the evening of the 13th and hived them.

I allowed them to fly on the 14th, but at 3 o'clock in the afternoon, they left the hive, and after settling first on one tree, then on another, finally settled on hive No. 1 (the original hive) and filed into the hive every one of them.

So I have now two colonies of fair strength which, to all appearances, are comfortably settled, and I have hopes of seeing a good honey flow in January, February, and March when there is a profusion of flowers in Lyallpur.

The swarming in December is attributed by Mr. Cousins to the heat inside the hive, and I think he is right as I was inclined to make them over-comfortable on account of the cold nights prevailing at the time.

I consider that the swarming was a good thing for me as I have now two hives and have moreover learnt quite a lot about my charges during this interesting period.

It also shows that one can increase the numbers of colonies in an apiary at a faster rate in the Plains than in the Hills, and this fact should be encouraging to would-be bee-keepers.

The issuing swarms, especially the first and second, were very numerous, and the original colonies did not look depleted after the swarming ; so far, therefore, everything has been propitious.

Since I started my first hive I have increased the number of frames in it from six to nine.

After the issue of the third swarm from my first hive I examined all the frames and cut out as many queen cells as I could find. They seemed to be all old ones, but I propose to keep on removing all embryo queen cells till February as it would certainly be inadvisable to have further swarming till then.

I think it is advisable to place on record an observation made this year with regard to *Apis florea*.

As I mentioned above, in the years 1915 and 1916 I noticed in the winter many colonies settled on the trees in and around my compound.

This year I have so far only noticed one and I fear the late rains are the cause of this reduction in their numbers.

The hive used by me is a Cowan-Cousins hive which has been evolved as the result of much experimenting and is the hive *par excellence* for *Apis indica* either in the Hills or the Plains.

***

THE FOOD-VALUE OF THE GROUNDNUT.

A Press Note, dated 6th November, 1917, issued by the Government of Bombay, says :—

The groundnut, pea-nut, earth-nut, or monkey-nut (*Arachis hypogœa*) is a leguminous creeping plant indigenous to India. Although the fruit resembles a nut in that it contains fat it is really a legume. After flowering, the stalk of the plant bends over and enters the soil, where the seeds grow and mature. These seeds are contained in paper-like pods or husks, and there are usually two, but in some varieties four seeds in each pod. For commercial use these nuts have to be decorticated, and the shell is usually broken by special machinery. The inner red skin covering the kernel is then removed as completely as possible by a blast of air. The separated and cleaned kernels are ground up and subjected to hydraulic pressure to obtain the oil. This oil, known as Arachis oil, or *Katchung oil* in India, is obtained either by two, or sometimes three expressions.

The first expression of oil takes place at the ordinary temperature, and yields a cold drawn oil, which is nearly colourless, has a pleasant taste and odour, and forms a most valuable substitute for olive oil. It keeps very well, but on exposure for some time it has a tendency to thicken, and only then does it turn rancid.

The second expression is carried out at a temperature of 30° to 32° C., and the resulting oil may be used for culinary purposes, for the manufacture of margarine, as a lubricant, and also for burning purposes.

The third expression requires a still higher temperature, *viz.*, 50° to 55° C., and this represents a lower grade oil, which is suitable for soap-making.

After expressing all the oil the press-cake is usually sold as a cattle food and is much valued as such, since it contains the highest protein content of all known cakes, and further has the advantage of easy digestibility. It is the purpose of this article to demonstrate the value of this cake as a foodstuff, and also the lines along which this industry may be developed with success.

In India, more particularly in the Bombay and Madras Presidencies, this groundnut industry is a large one, and before the war the nuts were exported from India in very large quantities, chiefly to France. Here the oil was expressed (of which from 45—50 per cent. is present in the Indian samples) and used for soap-making, and the result of this was that groundnut oil, or Arachis oil as it is commonly called, was cheaper in France than in India. The true kernel of the Indian groundnut has the following composition :—

	Grammes per cent.
Water	7·5
Protein	27·5
Fat (Arachis Oil)	44·5
Carbohydrates	15·7
Fibre	2·2
Ash	2·5

After the Arachis oil has been removed, and the resulting cake allowed to dry in the sun and finally reduced to a fine powder, this powder has the following composition :—

	Grammes per cent.
Water	9·8
Protein	44·5
Carbohydrates	23·8
Fat	9·2
Fibre	5·2
Ash	7·5

It is evident from the analysis that this groundnut meal represents a highly nutritious food, not only for cattle, but for human beings. At present this press-cake is either used as cattle food or as a manure. Now this flour is not only rich in proteins which are essential constituents of all foods, but these same proteins have a peculiar composition, which make them particularly effective in supplementing food products of cereals whose proteins lack these special constituents. The proteins in our ordinary food are built

up of certain amino-acids which are linked together just like the building stones of a house. Now all proteins contain these amino-acids, or building stones, but some essential ones are missing from the proteins of certain foods, and others again are present in varying proportions. Thus it has been shown that neither animals nor men can maintain their body, weight and proper growth and nutriment when fed on maize, or certain legumes. Similarly the proteins in wheat and barley, whilst sufficient to maintain body nutriment, will not suffice to promote growth. The first two have been shown to be due to the absence of a certain building stone, an amino-acid known as tryptophane, and the second two proteins to an absence of another building stone known as lysine. In order therefore to maintain proper nourishment and growth, the proteins taken in with the food must contain these two amino-acids, *viz.*, tryptophane and lysine, and it is because meat proteins satisfy this condition that they form such a valuable food. Now it is well known that vegetable proteins will not replace animal proteins in a dietary, and hence a perfect food must be made up so that all these building stones are not only present, but also occur in suitable proportions.

Now, we find that groundnut cake, besides containing a high proportion of protein, contains certain amino-acids in quantity. These amino-acids belong to the same group as those found to be deficient in the proteins of wheat and barley, *viz.*, lysine. By mixing groundnut meal with wheat flour and other cereals we are able to add these missing building stones. Again the particular proteins in the groundnut meal are deficient in the amino-acid tryptophane, so in order to overcome this deficiency we add dried milk in certain proportions. The groundnut cake when mixed with dried milk therefore gives us a flour of very high protein content; these proteins contain, as far as we know, all the various building stones necessary for growth and maintenance of nutrition. We find, however, that these two constituents do not go into solution very readily, hence the flour is mixed with sodium carbonate or bicarbonate, in which the other two constituents are readily soluble. The new flour thus consists of groundnut cake, dried milk, and bicarbonate of soda. The bicarbonate of soda acts also as a

preservative, and assists in the process of baking. All these three constituents can be obtained in India in any quantity, and at a very cheap rate. The materials used may be prepared with the use of the existing mill machinery so that no additional outlay of capital is required.

Now, besides containing a large amount of protein, this new flour is rich in fat and mineral salts. Of the latter the most important feature is its richness in phosphates (phosphoric acid). In all foods mineral salts cannot be replaced by any of the other forms of nutritive material present, *e.g.*, proteins, fats, and carbohydrates. The carbohydrates and fats in the food supply the chief source of energy for the production of heat and work, and to a certain extent these may be interchanged, but neither of these nutritive constituents can replace proteins in the diet. The new flour is found to be deficient in carbohydrates so that for ordinary purposes of bread-making it is suggested that ordinary wheat flour be mixed with it in the proper proportion (3—1) to make up this deficiency. The resulting product has now the following composition :—

	Grammes per cent.
Water	6·8
Protein	15·9
Fat	10·3
Carbohydrates	66·0
Ash	1·0

This represents as nearly as possible a "perfect" food, and as such approximates very closely to a patent German food sold in India before the war at Rs. 6 per pound. This flour can be made in India at about one-twenty-fourth of the cost of the German product. If the wheat flour is not added, the new flour makes a valuable food for invalids and for patients suffering from diabetes and allied conditions.

Bread made from the new flour has been subjected to analysis, and sent out for trial. The results of these trials are very encouraging, as the bread is described as pleasant to the taste, easily manipulated, and possessing good keeping qualities.

The above account represents an attempt to bring forward evidence to show the possibilities of great improvement in the

groundnut industry. Not only can the production of Arachis oil be improved, but the resulting groundnut cake has a very high food value. The paper-like husks serve an useful purpose for stuffing mattresses and cushions, and also as a possible source of cellulose (55 per cent.) for paper-making, or as a source of fuel. The thin brown coating over the kernel may be used for manure, as also the ashes from the shells, if these are used as fuel. The leaves and branches of the plant form excellent fodder for cattle, and the groundnut cake also is a valuable cattle food. From the above account it will be seen that there is absolutely no waste in the groundnut industry, and for the oil alone the commercial value is great.

Now that the export trade is cut off, there should be a great demand for this oil in India as a substitute for olive oil, and there are several oil-crushing mills in this country capable of carrying it out. A glance at the figures of the Indian export trade before the war shows in what large quantities these oil-yielding nuts left the country. With the German sources of supply cut off by reason of our acquisition of most of their colonies in Africa, practically the whole trade in oil-containing seeds rests in the hands of the British Empire and America, two great allies. The whole groundnut industry in India has therefore a great future if properly worked, well supervised, and advantage taken of the means of utilizing all the various by-products.

For further details the reader may be referred to *Handbook of Commercial Products, Indian Section, no.* 24, Calcutta, 1893; *The Commercial Products of India,* 1908, *Sir George Watt*; Article in *Indian Journal of Medical Research,* volume IV, no. 4, April 1917, page 786.*

All inquiries on this subject should be addressed to the Secretary, Indigenous Industries Committee, Secretariat, Bombay.

***

A NEW CANE DISEASE.

A NEW cane disease is stated to have broken out in Porto Rico the last three seasons and to be spreading steadily. The one noteworthy and constant symptom is the peculiar mottling of the leaves,

* This article was reproduced in the *Agricultural Journal of India*, vol. XII, pt. III, p. 621.

which are marked with numerous white or yellow spots and stripes with irregular indefinite margin ; a comparison is in fact suggested with the Sereh disease, though the two do not correspond in detail. It has been found that the cuttings from affected canes invariably reproduce the disease, no matter how they are treated, or in what soil planted. The effect on the canes varies from reduced yields to total failure of the crop, while the resulting juice is liable to cause a good deal of trouble in the factory. No ordinary cane disease remedies have had any effect, and rotation of crops is advocated as a temporary expedient.—[The *International Sugar Journal*, November, 1917.]

*
* *

THE NITRATE POSITION.

We were not far out in surmising that the recent sale of German stocks in Chili would soon be followed by others of the same kind, for, according to a cablegram from Valparaiso, the German oficinas are making preparations for the immediate resumption of production, their output capacity being over 400,000 tons per annum, and the acquisition of new grounds enabling many native and English companies to increase their output. The total in Chili in the current nitrate year ending June 30, 1918, will exceed the record figure of 63,209,000 quintals reached in the preceding twelve-month. The largest annual total before the war in 1913-14 was 62,323,000 quintals (2,833,000 tons), suddenly reduced to 33½ million quintals in 1914-15 through the outbreak of hostilities in Europe and the temporary shutting down of most of the works on the West Coast of South America. The principal agricultural outlets for nitrate of soda were closed, but, thanks to the enormous demand for the article for munition-making, the void was filled, and, notwithstanding scarcity of tonnage, shipments have been on a commensurate scale. Stocks in Chili amount, however, as stated in our last issue, to about 900,000 tons, compared with 750,000 tons at October 1, 1913, the corresponding period before the world was turned topsy-turvy. It may be taken for granted that the Allies, especially the United States, will for some months to come make large purchases of nitrate

without looking too closely at the price ; it is equally certain that "after the war" the European countries will be anxious to restore fertility to their impoverished lands by a free use of artificial manures, among which nitrate of soda has hitherto deservedly taken a prominent part. The question is whether the farmer will be willing to pay the extraordinarily high prices to which the Chilean fertilizer has been pushed, partly by big freights and marine insurance premiums, partly by increased cost of production and the claim to exorbitant profits by producers ; these latter, suffering from "swelled head" through free sales to lavish Government buyers, seem to think that there is no limit to the value of their product, and within the last four months they have had the assurance to raise the f.o.b. price by about six shillings per quintal to 15*s*. 6*d*., or double that gladly accepted in normal times. As already stated in these columns, the cost of production has undoubtedly risen through higher wages, dearer fuel, bags, and all oficina requirements, the appreciation of the Chilean currency being also an unfavourable factor; but to nothing like an extent justifying so colossal an advance in selling prices, more especially in the face of heavy stocks and uncertain market prospects. Although tonnage cannot be plentiful for some time after the cessation of hostilities, shiproom will eventually be obtainable on easier terms, and rates of insurance will come down with a run ; but unless values in Chili are also materially reduced, nitrate of soda will with difficulty compete successfully with its numerous rivals. The article on "Synthetic Nitrates," now appearing in this journal, sufficiently demonstrates the danger from that quarter, and the British farmer at all events is not likely to invest in the foreign fertilizer at 28*s*. (or more) per cwt. when, thanks to the Government, he can buy the richer home product—sulphate of ammonia—at sixteen shillings. The darkest "nigger in the fence" is probably and, perchance, appropriately of Teutonic origin, it being doubtful whether Germany, hitherto Chili's best customer, will resume her purchases of nitrate after the war, the following words from a recent speech of the Imperial Chancellor being, to say the least, ominous : "There are two matters of great moment to which I should like specially to allude. We

have had to import nitrate from Chili and pyrites from Spain for practically every ton of essential nitrates that we require. I have good hope of the schemes which are at present in hand for the use of gas works ammonia and for the production of cyanide, as well as otherwise for obtaining nitrogen. Germany has produced her nitrates without a ton from Chili." We leave it at that, merely opining that the nitrate outlook is somewhat opaque.—[The *Chemical Trade Journal and Chemical Engineer*, dated Oct. 20, 1917.]

***

PHYSIOLOGICAL EFFECT ON GROWTH AND REPRODUCTION OF RATIONS BALANCED FROM RESTRICTED SOURCES.

THE *Journal of Agricultural Research* (vol. X, no. 4) contains a further important contribution by E. B. Hart, E. V. McCollum, and other colleagues to the question of the physiological effect on growth and reproduction of rations balanced from restricted sources. Previous work has indicated that a ration can be complete and efficient only when it contains protein of adequate quantity and quality, adequate energy, mineral ingredients in proper quantity and proportion, and two factors (vitamines) of unknown constitution which have been temporarily designated as " fat-soluble A " and " water-soluble B." Later work now indicates that to these must be added the important factor of direct toxicity. This can be wholly absent or so mild in its effects as to be entirely obscured when the other essentials of a ration are at an optimum adjustment ; or with fair adjustment it may only reveal its effects when the ration is continued over a very long time and the animal involved in the extra strains of reproduction and milk secretion. Rations composed exclusively of wheat products (grain and straw) did not sustain growth with Holstein heifers. Such animals also failed to show œstrus and could not be bred. Marked pathological conditions resulted, such as blindness, feeble and emaciated condition, and abnormal excitability followed by collapse. The responsibility was found to be due in part to the inadequate salt mixture provided by the ration, and in part to inherent toxicity in the grain. By the use of maize stover or alfalfa hay as roughage in place of the

wheat straw growth was sustained, but reproduction was only partially successful, weakness commonly appearing in the second gestation. Maize grain *plus* wheat straw allowed sustained growth, but at a slow rate. Additions of salts to this ration made it normal. Addition of wheat embryo to a maize ration caused disturbances, bringing about early abortions, thus indicating a high content of the toxic material in the wheat kernel.—[*Nature*, 6th December, 1917.]

***

PROHIBITION, REGULATION, AND RESTRICTION OF IMPORT INTO BRITISH INDIA OF CERTAIN PLANTS AND SEEDS.

THE following notification, dated 7th November, 1917, has been issued by the Government of India in the Revenue and Agriculture Department :—

No. 13-C.—In exercise of the powers conferred by section 3, sub-section (*i*) of the Destructive Insects and Pests Act, 1914 (II of 1914), the Governor-General in Council is pleased to issue the following order for the purpose of prohibiting, regulating, and restricting the import into British India of the articles hereinafter specified.

1. In this order :—

(*i*) "official certificate" means a certificate granted by the proper officer or authority in the country of origin ; and the officers and authorities named in the third column of the Schedule are the proper officers and authorities to grant in the countries named in the second column the certificates required by the provisions referred to in the first column thereof ;

"plant" means a living plant or part thereof but does not include seeds ; and

"prescribed port" means any of the following ports, namely, Bombay, Calcutta, Dhaneshkodi, Karachi, Madras, Negapatam, Rangoon, and Tuticorin ;

(*ii*) all provisions referring to plants or seeds shall apply also to all packing material used in packing or wrapping such plants or seeds.

2. No plant shall be imported into British India by land or sea by means of the letter or sample post.

3. No plants other than fruits and vegetables intended for consumption, potatoes and sugarcane shall be imported into British India by sea except after fumigation with hydrocyanic acid gas and at a prescribed port:

Provided that plants which are infested with living parasitized insects and are intended for the introduction of such parasites may be imported without such fumigation if they are accompanied by a special certificate from the Imperial Entomologist to the Government of India that such plants are imported for the purpose of introducing such parasites.

4. Potatoes shall not be imported into British India by sea, unless they are accompanied by—

(*i*) a certificate from the consignor stating fully in what country and in what district of such country the potatoes were grown and guaranteeing that warty disease was not known to exist on the farms where the potatoes were grown; and

(*ii*) an official certificate that no case of warty disease of potatoes has been known during the twelve months preceding the date of the certificate within five miles of the place where the potatoes were grown.

5. Rubber plants shall not be imported into British India by sea unless they are accompanied by an official certificate that the estate from which the plants have originated or the individual plants are free from *Fomes semitostus* and *Sphărostilbe repens*.

6. Sugarcane shall not be imported into British India by sea unless it is accompanied by an official certificate that it has been examined and found free from cane borers, scale insects, Aleurodes, root disease (any form), pine-apple disease (*Thielaviopsis ethaceticus*), "Sereh" and cane gummosis:

Provided that canes for planting intended to be grown under the personal supervision of the Government Sugarcane Expert, may be imported direct by such expert without such certificate.

7. Coffee plants shall not be imported into British India by sea from America (including the West Indies) except by the Madras Department of Agriculture.

8. Seeds of coffee, flax, *berseem*, and cotton shall not be imported by land or by sea by letter or sample post.

9. Coffee seeds shall not be imported into British India by sea from America (including the West Indies) except by the Madras Department of Agriculture.

10. Flax seeds and *berseem* (Egyptian clover) seeds shall not be imported into British India by sea, unless the consignee produces before the Collector of Customs a license from a Department of Agriculture in India in that behalf.

11. Cotton seeds shall not be imported by sea except after fumigation with carbon bisulphide and at a prescribed port.

SCHEDULE.

1	2	3
Paragraph	Country of Origin	Authority
4 (*ii*)	Great Britain and Ireland ..	The Board of Agriculture and Fisheries, England. The Board of Agriculture for Scotland. The Department of Agriculture and Technical Instruction for Ireland.
	Sweden	The Ministry of Agriculture.
	Norway	The Norwegian Board of Agriculture.
	Denmark	The Ministry of Agriculture.
	France	The Ministry of Agriculture.
	Japan (including Formosa) ..	The Department of Agriculture and Commerce.
	Italy	The Ministry of Agriculture.
	British East Africa ..	The Department of Agriculture.
	Australia	The Departments of Agriculture, Victoria, South Australia, New South Wales, Queensland, Tasmania, and Western Australia.
5	Ceylon	The Department of Agriculture.
	Malay Peninsula ..	The Department of Agriculture, Federated Malay States.
	Dutch Indies	The Department of Agriculture, Industry and Commerce.
	Belgian Congo .. .	The Department of Agriculture.
	British East Africa ..	The Department of Agriculture.
	Uganda Protectorate ..	The Department of Agriculture.
	Nyassaland	The Department of Agriculture.
	South Africa	The Union of South Africa Department of Agriculture.
6	Dutch Indies	The Department of Agriculture, Industry and Commerce.
	Mauritius	The Department of Agriculture.
	Philippine Islands ..	The Bureau of Agriculture.

SCHEDULE.—(*Continued.*)

1	2	3
Paragraph	Country of Origin	Authority
	Japan (including Formosa) ..	The Department of Agriculture and Commerce.
	South Africa	The Union of South Africa Department of Agriculture.
	Egypt	The Ministry of Agriculture.
	West Indies	The Imperial Department of Agriculture, Barbados
	British Guiana	The Department of Science and Agriculture.
	Trinidad	The Department of Agriculture.
	Jamaica	The Department of Agriculture.
	United States	The Department of Agriculture.
	Ceylon	The Department of Agriculture.
	Malay Peninsula ..	The Department of Agriculture, Federated Malay States
	British East Africa ..	The Department of Agriculture.
	Queensland .	The Department of Agriculture and Stock.

***

Government of India, Department of Revenue and Agriculture, Notification No. 215-*C. dated the* 8*th February,* 1918.

In exercise of the powers conferred by section 3, sub-section (*i*) of the Destructive Insects and Pests Act, 1914 (II of 1914), the Governor-General in Council is pleased to direct that the following proviso be added at the end of clause 2 of the order issued with the Department of Revenue and Agriculture Notification No. 13-C, dated the 7th November, 1917 :—

"Provided that sugarcane for planting intended to be grown under the personal supervision of the Government Sugarcane Expert may be imported by him by such post."

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

THE following honours in the New Year's List will be of interest to the members of the Indian Agricultural Service :—

K.C.S.I. Mr. F. G. SLY, I.C.S., C.S.I., at one time Officiating Inspector-General of Agriculture.

C.S.I. The Hon'ble Mr. C. E. A. W. OLDHAM, I.C.S., formerly Director of Agriculture, Bengal ; and Mr. L. J. KERSHAW, C.I.E., formerly Secretary, Revenue and Agriculture Department, Government of India.

C.I.E. Mr. A. LANGLEY, I.C.S., formerly Registrar of Co-operative Societies, Punjab.

To all these gentlemen we offer our hearty congratulations.

***

MR. M. WYNNE SAYER, B.A., Assistant to the Agricultural Adviser to the Government of India, is with effect from the forenoon of the 6th February, 1918, placed in charge of the work of the Imperial Agriculturist in addition to his own duties during the absence on deputation to Mesopotamia of Mr. G. S. Henderson, N.D.A., N.D.D., Officiating Imperial Agriculturist, or until further orders.

***

MR. DAULAT RAM SETHI, M.A., B.Sc., Deputy Director of Agriculture in charge of the Orissa Circle, is confirmed in the Indian Agricultural Service with effect from the afternoon of the 30th October, 1917.

This officer was granted privilege leave for one month from the 13th December, 1917.

MR. N. S. McGOWAN, Professor of Agriculture, Sabour College, has been granted combined leave for one year with effect from 2nd February, 1918, or any subsequent date on which he may avail himself of it.

***

MR. A. W. FREMANTLE, Special Officer in charge of Ravine Reclamation, United Provinces, has been granted extraordinary leave without allowances for two months in continuation of that already granted to him.

***

MR. G. EVANS, M.A., Deputy Director of Agriculture, Northern Circle, Central Provinces, has joined the Indian Army Reserve of Officers with the rank of Temporary Captain. He has been placed on recruiting duty.

***

MR. D. BALAKRISHNA MURTI, Assistant Director of Agriculture, First Circle, Madras Presidency, was granted privilege leave for three months from or after 15th January, 1918, Mr. S. V. Thirumuruganatha Pillai acting in his place.

***

MR. A. L. SHEATHER, B.Sc., M.R.C.V.S., Director and First Bacteriologist, Muktesar Laboratory, is confirmed in his appointment with effect from the 4th October, 1917.

***

MR. S. G. M. HICKEY, M.R.C.V.S., 2nd Superintendent, Civil Veterinary Department, United Provinces, is confirmed in the Civil Veterinary Department.

***

MR. H. E. CROSS, M.R.C.V.S., D.V.H., A.Sc., Civil Veterinary Department, on reversion from military duty, was granted combined leave for six months with effect from the afternoon of 1st September, 1917.

***

MR. W. A. POOL, M.R.C.V.S., is confirmed in the Civil Veterinary Department with effect from the 27th December, 1917.

PLATE XXI.

In Memoriam.

The Late Mr. C. W. MASON,
Formerly Supernumerary Entomologist, Pusa.

MR. JADEO SINGH GAREWAL has been appointed to the Indian Civil Veterinary Department with effect from 29th January, 1918, and is posted to the Punjab for training.

***

THE three new Assistant Professors recently sanctioned by Government for the Agricultural College at Lyallpur have all assumed charge of their duties.

***

IN MEMORIAM.

WE regret to announce the death of Mr. CHARLES WILLIAM MASON, which occurred on 28th November, 1917, at Zomba, Nyassaland, as the result of blackwater fever. Mr. Mason was born on 13th May, 1884, and, after eight years at Conyngham House School, Ramsgate, and Haileybury College, spent three years at the South-Eastern Agricultural College, Wye, where he passed both parts of the College Diploma and also gained the Botany prize in 1905 and a silver medal for the best entomological and botanical collections. In October 1906, Mr. Mason was appointed to the Indian Agricultural Service as a Supernumerary Entomologist, and in December arrived at Pusa, where he was stationed until January 1910, when he returned to England on termination of his agreement.

During his service in India he was chiefly occupied in an investigation of the food of birds, especially in relation to the value of birds to agriculture by their destruction of insect pests, and the third volume of the Entomological Memoirs of this Department is wholly devoted to a record of this work.

After his return to England in 1910 he studied for some time at the South-Eastern Agricultural College at Wye, and afterwards went to America as a Carnegie student to undergo further training in entomology. Subsequently he was appointed to succeed Mr. E. Ballard as Government Entomologist in Nyassaland.

He leaves many who will remember him as a cheerful and honest worker, an all-round athlete, and a good friend.

Reviews.

Plant Types for College Students.—By Father ETHELBERT BLATTER, S. J., Professor of Botany, St. Xavier's College, Bombay. Published by the Author. Price R. 1-8.

FATHER BLATTER has previously done excellent service to the cause of science by the production of text-books suitable for university and college students. He now comes forward with a book on the plant types prescribed for the science courses of the Bombay University. This little volume will save the student a great deal of reference to many larger works, and at the same time it does not in any way take from the student the work of observation and enquiry. Illustrations have been deliberately omitted in order that the student may make his own drawings. The book really takes the place of an expert demonstrator who tells the student what to look for and leaves him to find the things mentioned.

Short historical and economic notes on the various plants serve to link up the more purely botanical matter with general knowledge and common life. The study of types is a method of teaching of comparatively recent origin, and has much to recommend it. The student studies intensively a few plants, and is taught rigid accuracy of observation and completeness of analysis of these few typical plants. The result is a training in method which can be applied at will to any other plant or problem. No one claims that it is the only method, but it is a very necessary part of a sound biological training. The volume under review is a most useful aid in the application of this method.—[W. B.]

The Agricultural Problems of India.—By RAI BAHADUR GANGA RAM, C.I.E., M.V.O. Simla Art Press.

RAI BAHADUR GANGA RAM, late of the P. W. D. and now a big zemindar on new Canal Colony land in the Punjab, has written a thoughtful work which will be read with interest by many who are connected with agriculture in India. The book consists of 60 pages, dealing generally with the subjects of poverty, famine, land revenue, irrigation, and agriculture. As an appendix there is a mass of tables taken from revenue and irrigation reports: some of these will doubtless be useful to seekers after knowledge.

Among some of the novel ideas are "the abolition of the present land revenue system and the substitution of a produce tax of $\frac{1}{6}$th of all produce of the land, the duty to be charged on all produce brought to the railway station"; and "that exemption from land revenue might be bought by any landowner for a cash payment of 30 years' tax, the money so obtained to be paid into Indian banks, the banks to pay the Government revenue from the interest, and use the principal to finance Indian industries."

The author does not, however, tell us from what source the huge sums necessary to redeem the tax are to be produced by the zemindar. There are not many parts of India, except Canal Colonies, where money is plentiful.—[G. S. H.]

***

All about the Mango.—By V. R. GADGIL, B.AG., 241, Sadashiv Peth, Poona. Price As. 12.

THIS little book is the first of a series in Marathi, dealing with the important fruit crops of India which the author contemplates to bring out. It contains a concise summary of the most important facts about the propagation and cultivation and diseases of the mango. Numerous references to current literature in India and elsewhere, and a bibliography, are given and bear testimony to the pains the author has taken to bring the book up to date. A detailed calendar of the operations to be carried out on a mango plantation from month to month, given at the end of the book, greatly adds to its practical utility.—[S. L. A.]

Correspondence.

To the Editor,

The Agricultural Journal of India.

Sir,

Lord Willingdon in his interesting article on the Ganeshkhind Dairy Herd (vol. XIII, no. 1) makes the recommendation that young stock should never be tied up. I suppose breeds differ considerably in their docility, but it is more general opinion in my experience that unless an animal has been used to tying and the handling it entails, she is likely to be unruly when brought into the herd, and that it is better to accustom them to this at an early age. Perhaps others could give their experience on this rather important point.

Coimbatore :
January 27, 1918.

Yours faithfully,
R. Cecil Wood.

To the Editor,

The Agricultural Journal of India.

Sir,

In your issue of October last my friend Mr. W. Roberts of Lyallpur, in the first instalment of the account of his recent visit to Egypt, America, etc., makes a reference to me, which, I think, calls for a brief reply. Mr. Roberts is speaking of the relative density of cotton bales in India, America, and Egypt, that in India being the highest, and goes on to say, " In this connection, ' The

World's Cotton Crops' by Professor Todd, page 126, may be consulted from which a different impression is gathered." Knowing that I had never expressed any opinion about the Indian bale, I turned to the page in question, to find that it deals exclusively with the comparative merits of the American and Egyptian systems of handling the crop throughout from the field to the ship's side. The question of baling is only one part of that system, and the mention of the fact that the Egyptian bale possessed a much higher density than the American bale was not in the least intended to convey, and I think would not convey, any comparison of either with the Indian bale.

All that I said elsewhere in the book about the Indian bale is on page 40 as follows: "It is well pressed, the exact density given varying according to the destination of the bales. Those for Europe are most heavily pressed."

Yours faithfully,
JOHN A. TODD.

NOTTINGHAM:
November 12, 1917.

TO THE EDITOR,

The Agricultural Journal of India.

SIR,

In submitting the attached letter which appeared in the *Times of India* for publication in the *Agricultural Journal of India,* I should be pleased if in view of your invitation for criticisms you would allow me to make a few comments on the article "The Problem of Sugar Manufacture in India" which appeared in the last October issue of the *Journal.** It is stated that "the main point is that even with the existing varieties and the present low yields of cane per acre it is possible, to make the industry more

* Vol. XII, pt. IV, p. 550.

remunerative to the cultivator, to increase the supply of *gur*, and make more raw sugar available in this country for refining."

In a paper on "The Sugar Industry" submitted to the XIth Industrial Conference held in Bombay in December 1915, the writer clearly showed that the refining of cane *gur* was not the method to employ to make sugar manufacture a financial success and that cane *gur* should only be made for consumption in that state.

To the attempts to manufacture sugar profitably by refining cane *gur* is chiefly due the backward state of the sugar industry in this country, as the process is against all the principles of economics, for it must be evident that unless a refinery can purchase a superior quality of cane *gur* at a cheap rate, when normal prices of sugar prevail, it will not pay to refine it on account of the enormous wastage and the high cost of refining, and if the ryot has to sell his *gur* at a cheap rate to a refinery which allows him little or no profit, he has no inducement to grow cane or make *gur*.

Where there is no cane sugar factory to which the ryot can send his cane, which can afford to pay him a price that will give him a reasonable profit through manufacturing sugar by the direct process, he must confine himself to making *gur* in the most economical manner possible for the *gur*-eating market, but he cannot be expected to be able to purchase and employ for this purpose such machinery as is used in large cane sugar factories for the simple reasons that he has not the capital, neither could he work the machinery if he had it, even if he had the large area of cane required to keep such plant as steam mills with Krajewski crushers and Triple Effect evaporators continuously at work during the cane season. For making *gur* the ryot having, say, 100 acres of cultivation cannot do better than employ crushing mills driven by oil-engines, and juice-boiling pans in which the juice would be boiled rapidly to the desired consistency, as the employing of steam boilers and engines would necessitate the employing also of a mechanic holding a certificate under the Boiler Act, which it is very doubtful if the average ryot is prepared to do.

The co-operation of several ryots is entirely another matter, for such co-operation would be equivalent to the forming of a

company to establish a factory which would deal with the cane from each of their holdings, and it is very doubtful for obvious reasons if it would be a success, unless it was under European management.

For the average ryot it would seem, therefore, that the method recommended above and as employed at the Manjri Farm cannot be improved on, unless a more rapid juice-boiling pan were to be employed of the tubular type such as established very successfully by the writer about ten years ago in the Madras Presidency. This rapid juice-boiling pan was made locally and used as an evaporator, the ordinary juice-boiling pans being used for finishing the boiling. The result was a good light-coloured jaggery or *gur* which fetched a good price in the *gur*-eating market.

In order to develop the sugar industry of the country the idea of refining cane *gur* must be given up. It is quite a different thing to refine the jaggery made from the palmyra tree juice which can be purchased cheaply owing to there being no cost for cultivating. This jaggery is largely used for refining purposes in the large refineries in the Madras Presidency to which the writer was attached for five years, but the large quantity of molasses produced in refining this jaggery necessitates the business becoming a distilling business as well, otherwise the refinery would not pay. The cane sugar manufacturing side of this refinery has been considerably developed within recent years, white sugar being turned out without using animal char the employment of which becomes necessary if a white sugar is to be obtained from *gur* or jaggery, thus increasing the cost of production.

As correctly pointed out in "The Problem of Sugar Manufacture in India," the most urgent reform required is on the manufacturing side, and there is no place in the whole of India more suitable for developing the sugar industry on a large scale than the Bombay Deccan, if only the land could be obtained.

CUMBALLA HILL: BOMBAY, Yours faithfully,

December 29, 1917. A. E. JORDAN.

Letter dated 26th December, 1917, by Mr. Jordan to the editor of the *Times of India* :—

In the written evidence submitted by the Indian Merchants Chamber to the Industrial Commission the following suggestion occurs :

"(*b*) If sugar cultivation is to spread and the sugar industry to become successful the Abkari system must be changed.

"The utilization of molasses is necessary if a sugar factory is to work at a profit. Rum should, therefore, be allowed to be manufactured from the molasses. Unless this concession is granted a sugar factory is not likely to prove a success financially."

There can be no question that it is more profitable for a sugar factory to have a distillery attached to it in order to convert the exhausted molasses into spirit, but if the cane sugar industry is to be developed on a large scale in the Bombay Presidency, as it must be, for India to become self-contained in the matter of sugar production and even an exporting country, it may not be practicable, or even advisable, for a distillery to be attached to every sugar factory it is proposed to establish.

In view of the evidence submitted by the Indian Merchants Chamber it may, therefore, interest its members who take an interest in the important industry to know that a sugar factory can be financially successful even without a distillery if the factory be of the proper kind.

The correctness of this statement by the writer who claims to be an expert in sugar factory design and in sugar manufacture, is borne out by the following :—

There are two types of sugar factories—the first a cane sugar factory which manufactures white sugar by the direct process from the cane and which utilizes the refuse crushed cane as fuel for generating the steam necessary to run the factory, thus producing the maximum quantity of sugar and the minimum of molasses at the minimum cost of production ; the second is a sugar refinery which manufactures sugar by refining the *gur*, or raw sugar, made by the ryots, from which only about 40 per cent. and frequently less of marketable sugar is obtained and to obtain which coal has to be

used as fuel, thus producing the minimum quantity of sugar and the maximum quantity of molasses at the maximum cost of production.

The former type of sugar factory, if properly designed, erected in the proper place, and efficiently managed, can be a financial success without a distillery; while the latter type of raw sugar refinery cannot be a financial success unless it has a distillery attached to it for converting the large quantity of molasses produced into spirit and this has been fully demonstrated by the number of such concerns that have been obliged to close in different parts of the country.

In "The Problem of Sugar Manufacture in India" by the Assistant to the Agricultural Adviser to the Government of India which appears in the last October number of the *Agricultural Journal of India*, it is stated, "as a matter of fact the factory at Pilibhit and the sugar factories in Bihar were running successfully even before the war. . . . . At present we import 61 lakhs of rupees worth of molasses, the by-product of sugar factories, and large quantities of molasscuit which is a cattle food prepared from molasses.

"If more sugar factories be opened in India they will be able to meet this demand and a license to manufacture rum will not be essential if steps are taken to develop the use of these by-products within the country itself."

The factories referred to are cane sugar factories of the first mentioned type and have no distilleries attached to them. It is also the case that in Mauritius, an island of about 750 square miles in area, there are about 60 cane sugar factories working on similar lines, run by Indian labour, and turning out 200,000 tons of sugar per season of five months, and none of these factories have distilleries attached to them, with the exception of one which manufactures a spirit for lighting purposes.

It would seem, therefore, once the necessary legislation is carried out which will enable the land to be acquired, that there is no reason why the Bombay-Deccan where such favourable conditions for cane cultivation prevail should not become a Mauritius or a

Java as far as the production of sugar is concerned, as Bombay possesses Marwaris and other capitalists bursting with money for which they require new fields of investment.

Notwithstanding the fact that a cane sugar factory can be financially successful without a distillery, yet for the development of the sugar industry in the Bombay Presidency it becomes advisable that the first factory to be established, or even a second, should have a distillery attached to it, to which the exhausted molasses from the cane sugar factories to be erected later could be sent instead of the country having to import molasses to the extent of 61 lakhs from Mauritius and Java for the purpose of manufacturing spirit in India.

TO THE EDITOR,

The Agricultural Journal of India.

SIR,

With reference to Mr. Jordan's letters, printed above, on the article entitled "The Problem of Sugar Manufacture in India," which appeared in the October (1917) Number of your *Journal*, I should like to make the following observations, taking his criticisms in order.

He criticizes the following sentence in my article : "The main point is that even with the existing varieties and the present low yields of cane per acre it is possible to make the industry more remunerative to the cultivator, to increase the supply of *gur*, and make more raw sugar available in this country for refining." This sentence has been taken from a paragraph in the article which emphasizes the absolute necessity for putting a stop to the enormous wastage—some 30 to 50 per cent.—which now goes on in *gur*-making.

Any improvement in this line will increase the *gur* production ; part of this may take the place of the molasses now imported from Java ; the rest will tend to glut the *gur* market and will make more *gur* available for refining.

In the case of surplus *gur*, refining is Hobson's choice.

Another point which has, I think, escaped Mr. Jordan's notice is the fact that in the Eastern parts of the United Provinces and Bihar which produce much *gur*, the product does not rank as eating *gur* but is only suitable for refining. Hence it sells for Rs. 2-8 per maund in average years.

The use of improved methods of *gur* boiling makes for a larger recovery of sugar when we come to refine. The low recovery at present is due to the caramelization which takes place in the open pan. This can be prevented to a great extent in an up-to-date *gur* factory.

It will thus be seen that the contention maintained in the article is that if the losses taking place in the mechanical part of the process are cut it will mean not only more income to the ryot but also a large increase in the out-turn of sugar and a consequent reduction in the imports from abroad.

The manufacture of white sugar direct from the cane has always been advocated in those areas where the supply of cane is constant and the quantity sufficient to supply a central factory economically, but in tracts where the cultivation is not concentrated *gur* must be made first irrespective of the fact whether it is eaten or refined afterwards, and if the cane cultivation cannot carry a *gur* factory then the Manjri system or other improvements advocated by the Agricultural Department can be employed.

With regard to the question of steam plant *versus* oil, which Mr. Jordan raises, comment is hardly necessary. The simple fact that the steam plant runs on megass and the oil plant requires fuel from a distance is, I think, conclusive. The present price of oil will soon shut down most oil-driven plants which work on a small margin, and there is no comparison between the difficulties of getting cheap oil and a boiler certificate.

I would also point out that nowhere in my article is the ryot recommended to run his own manufacturing plant. It should only be as a last resort in those areas where cultivation is so scattered as to make any other arrangements unworkable.

The following cuttings make interesting reading and, I think, bear out further what is maintained in my article.

The report of the Cawnpore Sugar Works for the year ending December 31st, 1917, is a very satisfactory one. Notwithstanding unfavourable results at both the company's distilleries a profit has been earned of Rs. 8,26,281 which enables dividend and bonus to be distributed on the ordinary shares at the rate of 35 per cent. While the war lasts Indian sugar companies should do well, since the imports of foreign sugar are restricted.

The report of the Champaran Sugar Company, Limited, for the year ended 30th June, 1917, shows a profit, after providing for commissions, bonus to cane-growers, and taxes, of Rs. 2,48,319-11-10, including Rs. 12,756-3-10 carried forward from previous year. The Directors recommend that Rs. 30,000 be placed to the Depreciation Fund, Rs. 75,000 be transferred to the Reserve Fund, Rs. 48,000 be spent in payment of dividend at the rate of Rs. 8 per share (Rs. 100), Rs. 72,000 be spent in payment of a bonus of Rs. 12 per share, and Rs. 23,319-11-10 be carried forward. 24,000 tons of canes were treated during the season as compared with 16,404 tons during the preceding year. The crop yield was 9·3 tons per acre, which, although better than the previous year's yield, was much below the average owing to unfavourable weather conditions.

The report of the Ryam Sugar Co., Ltd., for the year ended 30th June, 1917, shows a profit of Rs. 1,79,491-11-7, after providing for debenture interest, commissions, and taxes. The Directors after proposing to transfer Rs. 75,000 to the Reserve Fund recommend a dividend of Rs. 8 and a bonus of Rs. 2 per cent.; Rs. 13,685-0-7 will be carried forward to next year's account. Manufacturing results show an improvement on the previous season and satisfactory results have been realized for the Company's manufactures.

PUSA: Yours faithfully,

February 21, 1918. WYNNE SAYER.

NEW BOOKS.

1. The Wheat Problem, by Sir W. Crookes. Third Edition, with Preface, and an Additional Chapter, bringing the Statistical Information up to date, and a Chapter on Future Wheat Supplies, by Sir R. H. Rew. Pp. xvi+100. (London: Longmans & Co.) Price 3*s*. 6*d*. net.

2. The Chemical Constitution of the Proteins, by Dr. R. H. A. Plimmer. In three parts. Part I., Analysis. Third Edition. Pp. xii+174. (London: Longmans & Co.) Price 6*s*. net.

3. A Handbook of Nature Study and Simple Agricultural Teaching for the Primary Schools of Burma, by E. Thompstone, B. Sc. Pp. xi+279. With 115 Illustrations. (Longmans, Green & Co.)

4. Organic Evolution, by Prof. R. S. Lull. Pp. xviii+729. (New York: The Macmillan Co.; London: Macmillan & Co., Ltd.) Price 3 dollars.

5. The Anatomy of Woody Plants, by E. C. Jeffery. Pp. x + 478. (Chicago: University of Chicago Press; London: Cambridge University Press.) Price 4 dollars net.

6. A Dictionary of Applied Chemistry, by Sir Edward Thorpe. New Edition. Thoroughly Revised and much Enlarged. In five volumes. Price 50*s*. net each.

7. An Introduction to the Chemistry of Plant Products, by Paul Haas and T. G. Hill. Second Edition. With Diagrams. Price 10*s*. 6*d*. net.

8. Vegetable Forcing, by R. L. Watts. Pp. xx + 431. (New York: Orange Judd & Co.) Price 2 dollars net.

9. The Chemistry of Linseed Oil, by J. Newton Friend. Pp. vii+96. (London: Gurney & Jackson.) Price 2*s*. 6*d*. net.

10. Cotton and other Vegetable Fibres: Their Production and Utilization, by Ernest Goulding. (London: John Murray.) Price 6*s*. net.

11. Manuring for Higher Crop Production, by E. J. Russell. (Cambridge University Press.) Price 3*s*. 6*d*. net.

12. Biology, by Prof. G. N. Calkins. Second Edition. Pp. viii+255. (New York: H. Holt & Co.)

13. The Study of Animal Life, by Prof. J. A. Thomson. Revised Edition. Pp. xvi+477. (London: John Murray.) Price 6*s*. net.

14. The Pasteurization of Milk from the Practical View Point, by C. H. Kilbourne. Pp. iv+248. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd.) Price 6*s*. net.

15. Modern Propagation of Tree Fruits, by Prof. B. S. Brown. Pp. xi+174. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd.) Price 6*s*. net.

16. Dairy Cattle Feeding and Management, by Prof. C. W. Larson and F. S. Putney. Pp. xx+471. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd.) Price 11*s*. 6*d*. net.

17. The Faith of a Farmer: Extracts from the Diary of William Dannatt, of Great Waltham. Edited with an Introduction by J. E. G. de Montmorency. Pp. xliii+249. (London: J. Murray.) Price 5*s*. net.

18. British Grasses and their Employment in Agriculture, by S. F. Armstrong. Pp. vii+199. (Cambridge University Press.) Price 6*s*. net.

19. Science and Education, Edited with an Introduction by Sir Ray Lankester, K. C. B. (London: William Heinemann.) Pp. 200. Price 1*s*.

20. Artificial Dye-Stuffs : Their Nature, Manufacture, and Uses, by A. R. J. Ramsey and H. C. Weston. Pp. ix+212. (London : G. Routledge and Sons, Ltd.) Price 3*s*. 6*d*. net.

21. A Critical Revision of the Genus Eucalyptus, by J. H. Maiden. Vol. IV, Part 1. (Sydney : W. A. Gullick.) Price 2*s*. 6*d*.

22. The Exploitation of Plants, Edited by Prof. F. W. Oliver. (London : J. M. Dent & Sons, Ltd.) Price 2*s*. 6*d*. net.

23. Histology of Medicinal Plants, by Prof. W. Mansfield. Pp. xi+305. (New York : J. Wiley and Sons, Inc.; London : Chapman and Hall, Ltd.). Price 13*s*. 6*d*. net.

24. Practical Cheese-making, by C. W. Walker Tisdale and W. E. Woodnutt. Pp. 182. (London : Headley Bros., Ltd.) Price 4*s*. 6*d*. net.

THE following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs.

1. The Inheritance of Characters in Rice, I, by F. R. Parnell, B.A.; G. N. Rangaswami Ayyangar, B.A.; and K. Ramiah, L.Ag. (Botanical Series, Vol. IX, No. 2.) Price R. 1-8 or 2*s*.

2. A Bacterial Disease of Wheat in the Punjab, by C. M. Hutchinson, B.A. (Bacteriological Series, Vol. I, No. 7.) Price As. 12 or 1*s*.

Bulletins.

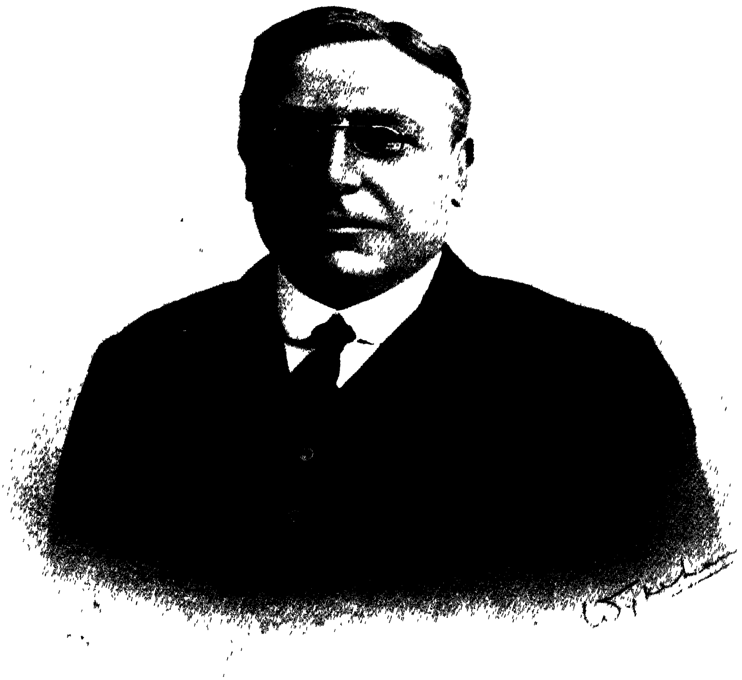
1. Second Report on the Experiments carried out at Pusa to improve the Mulberry Silk Industry, compiled under the direction of the Imperial Entomologist, by M. N. De. (Bulletin No. 74.) Price As. 4 or 5*d*.

2. Smuts of *Jowar* (*Sorghum*) in the Bombay Presidency, by G. S. Kulkarni, L.Ag., Assistant Mycologist, Department of Agriculture, Bombay. Price As. 4 or 5*d*.

3. Indigo Publication No. 1. A Study of the Indigo Soils of Bihar. The urgent necessity of immediate Phosphate manuring if crops are to be maintained, by W. A. Davis, B. Sc., A. C. G. I.

Reports.

1. Report on the Progress of Agriculture in India for the year 1916-17. Price As. 12 or 1*s*. 1*d*.
2. Report of the Proceedings of the Second Entomological Meeting held at Pusa on the 5th-12th February 1917. Price Rs. 3 or 4*s*. 6*d*.
3. Proceedings of the Board of Agriculture in India, held at Poona on the 10th December 1917 and following days (with Appendices). Price As. 13 or 1*s*. 3*d*.
4. Annual Report of the Imperial Bacteriologist, Muktesar Laboratories, for the year ending 31st March 1917. Price As. 5 or 6*d*.



SIR FRANK GEORGE SLY, K. C. S. I., I. C. S.,
Offg: Inspector-General of Agriculture in India, 1904-07.

Original Articles.

THE TRUE SPHERE OF CENTRAL CO-OPERATIVE BANKS.

BY

R. B. EWBANK, I.C.S.,

Registrar of Co-operative Societies, Bombay Presidency.

DURING the last few years there has been a distinct tendency in several Indian provinces to make the District Central Bank the pivot of co-operative administration. The tendency is perhaps most marked in the Central Provinces, the United Provinces, and Bihar and Orissa, but it is also discernible in Bengal and the Punjab and has on more than one occasion tinged the views of the Government of India itself. The theory that the District Central Bank cannot stop at the mere finance of local societies but should and must go further and assume general supervision and control over their management has in its most advanced form been eloquently advocated by Mr. H. R. Crosthwaite, C.I.E., in his book "Co-operative Studies and the Central Provinces System." The success of his system both within and outside the Central Provinces, backed by the vigour of his argument, has already made a deep impression on public opinion, and it appears probable that, unless some note of warning is sounded, the bias towards uniformity which sooner or later infects all official activities will bring the system universally into force throughout India. While several provinces remain uncommitted to this line of development, it may be worth while to pause and consider whether in the long run it is likely to lead to the bes possible results.

About the primary functions of District Central Banks in India, there is no room for difference of opinion. They have been defined by the Committee on Co-operation as the balancing of the surplus funds of affiliated societies and the provision of necessary capital. It is evident that these Banks cannot discharge the second function properly without some agency for inspecting the working of borrowing societies and estimating the extent of the credit that may legitimately be granted to them. A Central Bank needs therefore a field staff to verify the material assets owned by borrowing societies and to look into their general management and trustworthiness. It must have the means of judging independently the real needs of societies, the value of the security which they offer, and the amount that can usefully and safely be advanced to them. Otherwise their loans may do more harm than good, and may turn out in the end to be irrecoverable. Up to this point all co-operative authorities are agreed.

But in several parts of India Central Banks have extended their functions and powers far beyond this modest point. For instance, in many places the Board of a Central Bank is expected to undertake all propagandist work and the organization of new societies within its own area. It is to this board and particularly to its paid staff that new societies have to look for instruction, training, and advice. Through the Provincial Federation, where such exists, Central Banks have a large voice in the control of the auditing staff and every Bank is required to deal effectively with all audit notes on affiliated societies. They have to issue orders for the remedying of faults and to see that they are carried into effect. They are expected not only to control rural credit and stimulate thrift but to serve as centres of agricultural improvement and to carry on wholesale purchase and sale business on behalf of their clients. At the meeting of the Board of Agriculture in 1916 resolutions were actually passed that "The Registrar and Director of Agriculture should arrange for such practical training in agriculture as may be necessary and possible for the staff of Central Banks," and that "a Government official, subordinate to the Deputy Director of Agriculture, should be attached to each Central Bank which is

sufficiently developed." In order thoroughly to cement and rivet the intimate union of Central Banks with their affiliated societies, the latter are required to deposit their reserve funds and their individual members to subscribe to shares in the former. In fact primary societies have been delivered over, bound hand and foot, into the custody of Central Banks and enjoy just so much liberty as the Board of Directors may choose to allow to them. The Central Bank is leviathan and the local societies are the mere barnacles on its back.

This state of affairs has sprung from a theory of the essential unity of the whole movement which has been very forcibly put by Mr. Crosthwaite. "It cannot be too thoroughly understood that the credit enjoyed by each unit depends entirely on the stability and business reputation of the system as a whole. The correct view of your organization is that of an army with its general (the Governor of the Federation), its staff (the Federation Congress), its corps commanders (the Directorates of the Central Bank), its regimental colonels (the Committees of the Unions of primary societies), and its company officers (the Panchayats of the primary societies). Without a plan of campaign, without discipline, and without a responsible and guiding head, an army would be nothing but a disorderly mob, futile as a fighting machine. Without a definite policy, without co-ordination of effort, and without a liberal allowance of unselfishness, our co-operative system would be futile as a machine for the promotion of the economic welfare of the province. It is therefore the task of every educated co-operator to teach and train the men for whom he is responsible, to instil into them the virtues upon which the movement is based (and in the absence of which it cannot exist), and to set his face resolutely against the blighting influence of the parochial spirit." The gospel of centralization could scarcely be preached in more unequivocal language.

It is perfectly true that the credit enjoyed by each individual society is to some extent derived from the general credit of the whole movement, and that the failure of a society reacts on the credit of the whole group to which it belongs. Societies owe it to their

neighbours to obey certain rules of discipline and to maintain a certain average standard of efficiency, and where they fail to realize this, their neighbours are entitled in the general interest to interfere and to exact obedience. But beyond this the military analogy ought not to be pressed. The credit of each individual society is at least as much due to the integrity of its particular committee, the punctuality of its members, and the strictness of its management, as to the general reputation of the whole co-operative system to which it belongs. In the case of first-rate individual societies this fact is obvious, and even if all the local societies of a province are taken together, it will be found that in several provinces more than half of their total working capital is derived from local sources by the local credit of the committee rather than from central financing institutions. The key of the credit of the movement is in fact found in the individual village society, and not in the Central Bank. Mr. H. W. Wolff, the wisest and most far-sighted critic who has yet treated of the co-operative movement in India, has recently hinted [1] that co-operative credit in India seems to him to be getting near the danger zone on account of its "organization from top to bottom, threatening over-centralization, and interlinking of liability." He has made this point clearer in a later article.[2] "Central Banks are at present approving themselves as exceedingly useful. But they inevitably shift the centre of gravity for each local district from the place where it should be and where there is direct power of observation and control to another place where minutiæ cannot be observed. It is the Central Bank which is becoming the seat of responsibility, the checker of applications, the granter of credit. The local member in the primary societies loses the full mastery over his own liabilities. It is only in the local bank, managing its own affairs, that true co-operative education can be given, which is the greatest benefit bestowed by co-operation and which is surely nowhere more needed than in India."

---

[1] *Bengal Co-operative Journal*, vol. III, no. 4, p. 277.
[2] *Bombay Co-operative Quarterly*, vol. I, no. 4, p. 153.

No doubt local societies have their representatives on the Board of the Central Bank and have a large voice in its management. But that does not make control by a Central Bank the same thing as self-control under which every society is free to determine its own fate. The general credit of the system as a whole ought not to be made too much of a fetish. A few failures here and there will not appreciably affect it. If local societies are always kept in swaddling clothes and guarded from every natural accident and error with too grandmotherly a care, they will never learn to stand on their own legs. Mistakes are bracing. Provided that a guiding hand is ready to be stretched out when a society stumbles, it ought not to be protected too carefully against itself. The Act, rules, and by-laws form a sort of Manual of management, and the annual audit serves to show up all mistakes and infringements of the principles there laid down. In most cases the Local Union is at hand to warn and advise. If in addition to all this the Central Bank smothers a society with well-intentioned regulations and constant guidance, it saps its independence and in the long run may ruin it as a healthy economic organism. The true function of a Central Bank is simply to say " yes " or " no " to loan applications, and when it says " no " to explain why, in order that a society may know in what way its credit is defective. Owing to rural illiteracy, a Central Bank should perhaps go rather further in India and help societies which are incapable of helping themselves, to build up their credit and to earn the confidence of the financing institution. But they should not be permitted to usurp complete domination over the movement within their district. Their true sphere is finance and not administration and control. In the words of Mr. Wolff: " The Central Bank is, when all has been got ship-shape, to serve, not to be tutor to, the local banks. It is in fact designed to be a ' bank.' In Europe I prefer that it should be a joint-stock company. Its manager's proper business is that of bankers qualified to meet commercial bankers on their own ground and form a link between the co-operative and the banking world."

The main reason why so much power has been concentrated in some provinces in the Central Banks is no doubt the dearth

of educated men of enterprise and business ability outside the big towns. It was felt that the ryots were too feeble and ignorant to take full powers of management into their own hands for many years to come. The choice seemed therefore to lie between an immense increase in the official supervising staff and reliance on a committee of public-spirited non-official gentlemen controlling local societies through a bank at headquarters. The latter alternative was naturally preferred and in some banks very good work has been done. But experience has shown that this result is by no means universal. Mr. R. W. D. Willoughby, I.C.S., Registrar of Co-operative Societies, United Provinces, has in his last Administration Report criticized the system in language that is certainly not wanting in candour or vigour :—" The system to which we are committed in this province entrusts the finance, supervision, and indeed the whole fortunes of the movement to the District and Central Banks. These banks are administered by Boards of Directors who are predominately urban and professional. Such bodies are by their constitution ill-adapted to establish the intimate contact required for the fostering and training of such a delicate plant as the young village credit society or even for its control or finance when adult. The lawyer, banker, and other professional gentlemen can hardly be expected to find time constantly to visit villages, often distant, and to find out what his staff is doing there. They are inevitably dependent on their paid staff. Now no committee of townsfolk can lend money with advantage or safety to a multitude of individual rustics whom they have never seen and never met and whose credit they cannot gauge through a staff whom they cannot check or control. The attempt is apt to result in the mere substitution of the urban middle class for the village money-lender as the usurer without advantage to either lender or borrower. For with an uncontrolled staff the effective rate of interest really paid tends to be quite as high as the bania's................Experience has continued to show that too many central societies regard their primaries rather as customers to be bled than as children to be fed." If this indictment be accepted as true, then it is clear that the system is already on the

verge of a break-down in one province and that there is a *primâ facie* case for examining the theory underlying it very carefully in the light of local conditions before encouraging its extension elsewhere.

A Central Bank is capable of undertaking banking business of every sort for its client societies, and of carrying out such inspection as is necessary for the assessment of credit, the punctual recovery of its loans, and other similar routine. In matters of finance centralization is not only unobjectionable but highly desirable ; and by its constitution the usual Indian Central Bank is well adapted to serve as the financial nerve-centre of its district. But when it widens its horizon and begins to stretch out tentacles towards the control of audit, training, organization, and propaganda, when in fact it centres all co-operative activity in itself and treats its ancillary societies as a company officer treats the soldiers under his command, then two great dangers begin to appear. Firstly, the Central Bank is trying to undertake more than it is fitted to perform, and is liable to overstrain its machinery and to break down, as has already perhaps happened in parts of the United Provinces. Secondly, the healthy growth of primary societies tends to be stifled by too much outside control. In many parts of India—certainly in large areas in Bombay and the Punjab—the ryots are substantial and independent men, perfectly competent to run their own societies once they have been shown how. A little adversity often stimulates them ; but frequent outside interference, not always quite disinterested, tends to enervate and dishearten them.

If the sphere of the Central Banks is restricted in the manner suggested, it will be asked what agency is available in their place to undertake the functions shorn off from them. The answer to this question entirely depends on local conditions. Except in matters of finance, where there are enormous advantages in a uniform system leading up in a pyramidal form from the local society through the local Central Bank to the apex Provincial Bank, uniformity as such ought to be shunned. The co-operative movement is a growing organism still half-developed. If it is cramped into a stereotyped frame, atrophy is bound to set in. Experiments should still be freely encouraged. The function of training and supervision so far

from being centralized like finance should be decentralized downwards. In Bombay Presidency it is being undertaken by small clusters of societies grouped in guaranteeing Unions on the Burma model, and in places where there are no Unions local co-operators and chairmen of first-rate societies are appointed as Honorary Organizers and Assistant Honorary Organizers and discharge these duties very zealously as a labour of love. General propagandism and the education of the public is being entrusted to a Central Co-operative Institute which is now under formation. When the time comes for societies to take over the duty of primary audit, it is intended to entrust it to federations of Unions, separately organized for each linguistic area. The Central Banks, under the enlightened guidance of the Bombay Central Co-operative Bank, have never sought to exceed the functions assigned to them by the Committee on Co-operation. Whatever the defects of this system may be, it has the merit of having left the primary society master in its own house, and of having made not the Central Bank but the local Union of primary societies the axis around which co-operative administration revolves. In other provinces other types of organization will no doubt be found more suitable. But the object of this paper will have been served if co-operators will think twice before acquiescing in any extension of the powers and influence of a Central Bank, which may convert it from the servant to the master of the co-operative societies within its area.

PLATE XXII.

INDIAN COTTON COMMITTEE.

Standing: Mr. H. F. Ashton (Punjab Irrigation Department); Mr. G. S. Henderson, I. A. S.; Mr F. Noyce, I. C. S., (Secretary); Mr. W. Roberts, I. A. S.
Sitting: Mr. N. N. Wadia, C. I. E.; Mr. J. Mackenna, C. I. E., I. C. S., (President); Mr. F Hodgkinson.

THE EARLY HISTORY OF COTTON IN BOMBAY.*

BY

J. MACKENNA, C.I.E., I.C.S.,

Agricultural Adviser to the Government of India.

In December last I learned with great interest that a Students' Cotton Association had been formed in this college, the object of which was to study questions relating to cotton cultivation, manufacture and trade. Busy as I am, I had little hesitation in accepting the invitation to become its first President, for the formation of such an Association seemed to me a most hopeful sign of the times and to hold out great promise of future development. We are frequently told that one of the reasons why the development of Indian industry has been such a slow process has been the absence of *entrepreneurs* looking to the direction of organized industry as their natural source of wealth. To students of a College of Economics it is hardly necessary to explain the functions of an *entrepreneur* and I need only say that he is an essential link between capital and labour. Capital there is in India, if not in abundance, at any rate in large quantities, but it is often shy and difficult to secure. Labour there is, but it wants organization. Mr. Moreland recently pointed out, in an article in the *Quarterly Review*, which I expect many of you have read, the difficulties in regard to the supply of capital and the organization of labour in India. He added that to face these difficulties with a fair prospect of success required a combination of enterprise and experience which was unfortunately rare in India, and that this scarcity of men of the right sort was

---

* A lecture delivered to the Students' Cotton Association of the Sydenham College of Commerce, Bombay, on 28th January 1918.

probably the greatest single obstacle to the industrial development of this country. It appears to me that the existence of such a college as the Sydenham College of Commerce and Economics should have a great effect in removing this obstacle, and the formation of such an Association as that which I am addressing shews that there are many of you who are fully alive to the opportunities which are offered you here. The greatest need of Indian industry is men who are capable of shouldering responsibility: in the towns, competent managers of departments and foremen; in the country, competent men to place in charge of buying agencies and so on. The enterprise which has started this Association will, it is to be hoped and expected, not be entirely expanded within the walls of this college but will lead its members far when they go out into the world and remove one of the standing reproaches to Indian industry. A very successful commercial man of my acquaintance at home once told me that a piece of advice he was fond of giving to a young man starting work under him was that he should make it his aim always to qualify himself for the appointment of the man immediately above him. It struck me as a very sound piece of advice and I pass it on to you. Possibly it may assist in the production of a budding Tata or Wadia from among your ranks.

This is, as far as I know, the first Association of students which has been formed in India to study the cultivation and manufacture of, and the trade in, one particular product. Doubtless we shall shortly hear that Calcutta, not to be outdone by Bombay, has formed a Students' Jute Association, for jute is the only Indian industry at all comparable with cotton. If we do—well, wholesome rivalry is to be welcomed and a debate between the students of the two Associations as to the merits and importance of their respective fibres would, I am sure, attract a large and appreciative audience!

It was only natural that the first Students' Cotton Association should be formed in Bombay, for Bombay *is* the Indian cotton trade centre. In every respect, whether it be as regards cultivation, manufacture or trade, this Presidency is so easily ahead of all other provinces that it is a case of Bombay first and the rest nowhere. Figures are usually regarded as dull but they have their advantages

in proving a point, and I propose to give you a few for that purpose. I am not particularly fond of them myself and I have not therefore subjected myself to the labour of working out averages, but as the proportions are much the same whatever year you take, we will take the last for which statistics are available. In 1916-17, the area under cotton in the Bombay Presidency, excluding Sind, was 6,394,000 acres out of a total of 21,210,000 acres for the whole of India, that is, it was just under one-third. The only other province with any area under cotton at all comparable with this was the Central Provinces with 4,401,000 acres under cotton and that province forms part of the hinterland of this. The out-turn of cotton from Bombay was 1,519,000 bales out of a total of 4,557,000 bales. Passing next to manufacture, we find that the preponderance is even more marked. Of the 267 spinning and weaving mills in India in 1915-16, 175 were in this Presidency and 86 were in Bombay itself. Of the 6½ million spindles, over 4½ millions were in this Presidency and nearly 3 millions in Bombay itself. Bombay City had almost half the 108,000 looms in India and the Presidency over three-quarters of them. Of the 292,160 men, women, and children employed in the cotton mills in India, 189,630 were employed in this Presidency. These figures were, of course, reflected in the output. Of about 722½ million pounds of yarn produced in 1915-16, nearly 510 million pounds were produced in the Bombay Presidency. Of 352¼ million pounds of woven goods, about 287½ million pounds were produced in Bombay. There is, however, one respect in which Madras is ahead of you. With a very much smaller number of mills, it produces very nearly as much yarn of higher counts *i.e.*, counts above 40's, as the whole of this Presidency and considerably more than Bombay City. Having examined the figures of cultivation and manufacture, let us turn to those of trade. Of exports of nearly 9 million cwt. of raw cotton in 1915-16 valued at about £16½ millions, rather over 7 million cwt. valued at nearly £13½ millions went from Bombay. Of exports of about 160¼ million pounds of cotton twist and yarn valued at £4,600,000, no less than 151¾ million pounds valued at £4,378,000 were exported from Bombay. Of exports

of cotton piece-goods, of nearly 118½ million yards valued at £1,645,000, 84,140,000 yards valued at about £896,000 were exported from Bombay. Nearly all the handkerchiefs and shawls exported from India, in value about £100,000, went from Madras, but almost all the hosiery and sewing threads were supplied by Bombay. In the import trade, Bombay is not so predominant and Calcutta had a big lead in the matter of imports of piece-goods. This one would naturally expect, for coals are not usually sent to Newcastle, and this Presidency is obviously more self-reliant in regard to piece-goods than any other part of India. An import of piece-goods to the value of nearly £5½ millions is by no means negligible. The figures I have given you show, I think, gentlemen, your wisdom in starting an Association for the study of cotton cultivation, manufacture and trade and also what a vast field of enquiry lies before you.

I will now pass on to the main subject of my address. You will, perhaps, wonder why I have selected the "Early History of Cotton in Bombay" to talk to you about this evening. You may have thought that there were various more up-to-date aspects of the problems connected with cotton about which I could have spoken. There is, for instance, the agricultural aspect. We might have considered why the yield of cotton per acre in this country is so low compared with that of Egypt or America. I might have given you a description of the botanical work which has been done on cotton though that would have been a subject more suitable for a President with more scientific knowledge than I can claim. Of the processes of spinning and weaving, you can get sufficient ocular knowledge in this city. Then there are the eternal problems of mixing and adulteration of which so much has been heard recently. But a little reflection will shew you that I could not have addressed you on any of these topics without saying more than would have been advisable at this stage in regard to the views of the Committee of which I have the honour also to be President. That is the reason why I turned to the "Early History of Cotton" in this Presidency as a non-contentious subject, but I hope you will agree with me at the end of evening that a study of it has not been without its uses.

In a book on which I have largely drawn for my material, though I have also gone to most of the original sources from which it was compiled, "Cotton in the Bombay Presidency" by Walter R. Cassels published in 1862, figures are given for the import of Indian yarn into England from as far back as 1703. These were obtained from the records of the East India Company. The total imports in 1703 amounted to 114,100 pounds. Prices do not appear in the list until 1706 when they were 2*s.* 2¾*d.* per lb. In 1801, over 56,000,000 pounds of "cotton wool," presumably ginned cotton, were imported into England, of which just under 4,100,000 pounds were from India. In 1710, the imports had been only 710,000 pounds. It was the genius of Hargreaves, Arkwright and Watt that had brought about this tremendous increase in the demand for cotton. It is very interesting, though anything but cheering, to remember that the imports of Indian cotton had attained some importance long before any American cotton reached England. The first shipment of American cotton was made in 1747 from Charleston and consisted only of seven bales. In 1784, about 14 bales were shipped to England but were seized in Liverpool as contraband. So little was known about the capacity of the United States to produce cotton that it was believed that it could not possibly have been grown there. It was first shipped in any quantity in 1791 when 189,316 lb. were exported, and the exports have gone on increasing more or less steadily ever since. The extraordinary development of the export of American cotton was due more than anything else to the invention of the Whitney sawgin which holds the same place in regard to it as Arkwright's spinning frame does to the development of the cotton industry of Great Britain. The gin enabled one man to clean more cotton in a day than he had previously been able to get through in a month. The invention of the gin was received with very different feelings from those with which the replacement of hand labour by machinery was usually regarded in those days. A crowd, whose industry had been restrained by want of means to separate the lint from the seed with sufficient rapidity, broke into Whitney's workshop and carried off his machine before it was complete or he had been able to secure a

patent for it. The year after it was completed, the export of cotton from the United States increased nearly 40-fold and by 1805 it had increased about 240-fold.

The constantly increasing demand for cotton excited the interest of the East India Company which began to wonder whether it could not obtain a larger share of a lucrative trade. In 1788, which is one of the landmarks in the history of Indian cotton, the Court of Directors called the earnest attention of the Governor-General to the necessity of generally encouraging and improving the cultivation of cotton in India. They requested him to take steps, in conjunction with the Government of Bombay, to send them at once half a million pounds of the best Broach and Surat cotton and the same quantity every year. In 1790, the Government of Bombay estimated the total production for the Presidency at 33,712,000 lb., of which 26,656,000 lb. were exported. The best quality, they said, was produced in Jambooser, Ahmood, and throughout the Pergunna of Broach. At that time the Company received the cotton loose and packed it themselves. This enhanced the price four or five rupees a *khandi* but they calculated that the extra price was more than made up for by the prevention of fraud in packing and the avoidance of sandy or leafy parcels. In order still further to encourage the trade, the Court of Directors, at the end of 1790, authorized ships carrying convicts to Botany Bay to go to Bombay and to carry home cotton on private account "under the inspection and direction of the Company's servants at that settlement, provided such cottons were sold at the Company's sale, subject to the usual expenses." 422,207 lb. were sent to London as a result of these steps but the highest price fetched was $10\frac{1}{2}d.$ a pound which was not considered sufficient. A quantity of Surat cotton smuggled from Ostend did not in the phraseology of the day "turn to a more productive account." The Court of Directors thereupon expressed the opinion that "it is evident, therefore, notwithstanding the flattering allurements held out by British manufacturers, that the article will by no means answer." For the next few years, very little Indian cotton was imported into England but in 1799, encouraged by an improvement in prices, the

Court instructed the Bombay Government to fill up any spare tonnage with cotton. Prices, however, again went down and the permission to load cotton was rescinded unless other freight failed to be forthcoming in which case the orders were that empty space should be used for cotton rather than that these boats should be sent away dead-freighted.

In 1810, the Company purchased a quantity of cotton for export to China, whereupon two Bombay firms, Messrs. Forbes & Co., a firm which is as vigorous now as it was a century ago, and Messrs. Favatt & Co., protested that the Government purchases had raised the price of cotton to Rs. 175 per *khandi* on the Bombay green, a price which they considered ruinous. They begged Government to withdraw its competition for a season offering to form a secret convention to supply at its actual cost the quantity of cotton required for the China trade during the year. The proposal was warmly supported by two members of the Bombay Council, Messrs. Rickards and Lechmere, but the Court of Directors stoutly denied that they monopolised the market or that they had procured cotton below its proper value "which it was not in the interests of the Company to do." They expressed the opinion that "a more extraordinary proposal did not stand upon their records than this" which they considered "a secret combination between buyers to narrow competition." Messrs. Rickards and Lechmere were accordingly removed from the Council of Bombay. Let us hope that a better fate awaits the members of the Indian Cotton Committee!

During these years, the fortunes of Indian cotton varied with the exports of American cotton, as they have done in much more recent times. In 1809, in anticipation of deficient supplies from America, the Court authorized all private ships to bring more cotton from India to London and, in consequence, about 30 million pounds were shipped to England. Only 1¼ million pounds of it were used by British manufacturers and 3¼ million pounds were exported to the Continent. Even at that early period, therefore, the greater part of the Indian exports of cotton to Europe went to the Continent, as they do to-day. The balance of 25½ million pounds remained unsold in the Company's warehouses, and the Court complained

despondently of the adverse disposition manifested by British merchants in regard to it and, in the following year, that "it remained a ruinous and unproductive burthen both upon the Company and the private importers." They ordered that no cotton should be shipped to England on their account in 1812-13.

In consequence of these unfortunate experiences, the Court of Directors seem to have decided that their energies in regard to Indian cotton would be better directed towards an improvement in its staple. Some experiments with Bourbon cotton had been made in the Bombay Presidency from 1797 when Dr. Anderson was employed in distributing cotton seed from Mauritius and Malta throughout the Peninsula. A fresh supply was secured from Mauritius in 1812 and distributed to the Collectors of Broach and Surat. At that time, Bourbon plants were flourishing wild in the hedgerows of the Island of Salsette. I wonder how much cotton—wild or cultivated—there is to be found on Salsette nowadays. The first experiment on a large scale was made at Kaira in 1815 by an Assistant Surgeon named Gilders but "the slow growing perennial Bourbon attaining full vigour only in eighteen months persisted in the dry soil." A bale of cotton was, however, obtained from the experiment and consigned to London where it realized 1*s*. 5*d*. a pound or 2*d*. a pound more than the best Surat at the time. The next year, Mr. Gilders made a further experiment in the "Eastern Zillah between Subermuthy and Myhee," and obtained 44½ maunds of lint from 27 bighas of land. The cotton was valued at 2/3*d*. per pound in Bombay but only fetched 1/3*d*. in England against 5¾*d*. to 1/2¼*d*. for Surats. The expense of cultivating it was so great that there was a loss of 28 per cent. on the transaction. However, the Bombay Government considered the results sufficiently encouraging to justify their authorizing the Collector of the Eastern Zillah to offer a prize of Rs. 200 to the person who produced the greatest quantity of cotton of approved quality by a given period in the years 1819-20 from a given quantity of ground, with smaller prizes of Rs. 150, 100, and 50. These pecuniary inducements, however, met with no success.

Beyond the importation of two metal gins from Charleston in 1816, which were tried and reported to be unsuitable, nothing further seems to have happened till 1828. By that time the dependence of the British manufacturer on the American crop had become so marked that the desirability of finding a second if not an alternative source of supply could not be overlooked. Lord Ellenborough, the Chairman of the Indian Board, therefore suggested to the Court of Directors in 1828 "the expediency of attempting, on a small scale, the cultivation of all the finer sorts of foreign cotton in different and distant parts of India, under every different circumstances of soil and climate, and of transmitting to England, cleaned in the American manner, samples of the cotton so raised for comparison with the cottons of other countries." The Court of Directors, therefore, resolved to establish an experimental plantation at the cost of the State and directed the Bombay Government to select about 200 acres for the purpose to be placed under competent superintendence. They also directed that experiments on a small scale with the fine sorts of exotic cotton should be made in various parts of the Presidency, particularly in districts bordering on the sea coast. As a practical means of encouraging the cultivation of better cotton, they gave an order for 500 bales of the growing crop of Broach or Surat cotton, "to be gathered and prepared with the greatest attention." They also sent out a good supply of fresh Georgian Upland and New Orleans seed as well as two Whitney's sawgins. Acting on these instructions, the Bombay Government established the two first experimental farms in India. One in Broach was placed under the superintendence of Mr. Finney whilst the experiments in the Deccan, Khandesh, and Dharwar were placed in charge of Dr. Lush. Mr. Finney's only qualifications seem to have been that he had had experience on an indigo plantation in Bengal; Dr. Lush had, at any rate, some botanical training as he had been superintendent of the Botanical Gardens at Dapoorie. Against the Court's order for 500 bales, only 300 bales of suitable quality were secured. Part of this was ginned by the Southern Mahratta foot-roller gin, part by the *churka*, and part by the sawgin. The staple of the latter was reported to have been cut to pieces in ginning

and it was valued at about $\frac{1}{2}d.$ a pound less than that ginned by the *churka* and from $\frac{3}{4}d.$ to a penny a pound less than that ginned by the foot-roller gin. Mr. Finney died shortly after his appointment and was succeeded by a Mr. Martin who opened a farm of 3,000 bighas of land at Danda which produced about 74 bales of cotton in 1832, of which 18 bales were shipped to London where the injury done to the staple by the sawgin was again the subject of unfavourable comment. In 1831, the American cotton seed "failed from an insect which deposits its eggs in the pod before it has arrived at maturity, producing a worm which destroys the cotton," the first record, I believe, in the history of Indian cotton of the appearance of the bollworm. Egyptian, Pernambuco and Bourbon seed were also tried at Danda. It is unnecessary to give the details of the experiments year by year. It is sufficient to say that when they were finally abandoned in 1836, the report on them was that "with the exception of the Pernambuco, the foreign seed generally failed or yielded produce scarcely superior as a merchantable article to the indigenous Broach or Surat cottons. The produce of the seed raised from the original foreign seeds was also marked by a gradual deterioration in quality in the growth of each successive year." Dr. Lush's experiments in the Southern Mahratta Country met with no better success. This point is specially worthy of mention, for I have frequently seen the introduction of Dharwar American cotton into this country placed to the credit of this gentleman. He started a farm at Seegee Hullee in the Dharwar District but it did not prosper. He reported that the soil appeared best adapted to the culture of the white-seeded perennial, the Pernambuco and the Egyptian cotton, which last promised to succeed far better than the others. The entire crop available for shipment to England in 1831 only amounted to four bales, two of white-seeded perennial, one of American Upland, and one of New Orleans, and the value placed on them was from $7\frac{1}{2}d.$ to $8\frac{1}{2}d.$ per pound for "Candlewicks and jewellers' purposes." In 1835, undaunted by his failures, or as Mr. Cassels somewhat caustically observes, by his successes which were even more expensive than the failures, Dr. Lush proposed in 1835 to add about 1,000 acres to his Suggee Hullee

farm. The Bombay Government, however, declined to agree. Writing at the end of this year, Dr. Lush reported that, with the exception of the naturalized Pernambuco and a late trial with the Egyptian seed, all foreign cottons of long staple had become short. He added that the American sawgin had been a failure. In 1836, the Government of Bombay decided on the abolition of the experimental farms. Sir Robert Grant, the Governor, recorded his opinion that the experiment had been tried sufficiently and had failed. For the next few years Government contented itself with unsuccessful efforts to improve the *churka*. Nothing that had been done had so far made any impression on the ryots and Sir John Rivett Carnac, the Governor of Bombay, pointed out that no encouragement which had been extended could avail with them against the one circumstance that dirty cotton gave a better return than clean, an opinion which has been repeated at intervals ever since.

In 1838, the state of affairs at home once again caused attention to be turned to India. Urgent memorials were submitted to the Court of Directors by the Chambers of Commerce of Manchester and Glasgow and the East India Associations of Liverpool and Glasgow and were forwarded to the Governor-General with a despatch in which the members of the Court signed themselves "Your affectionate friends," a form of signature which it is to be regretted has fallen out of use in official correspondence. It is certainly somewhat less stilted than "We have the honour to be, Sir, Your most obedient servants."

The next step, and a very bold one, determined on by the Court of Directors, was the engagement of American planters for the purpose of instructing the cultivators of India in the cultivation and proper method of cleaning cotton. Captain Bayles of the Madras Army was deputed to engage experienced and competent men. India was then, I need hardly say, a much more unknown country in the United States than it is now, and, as was to be expected, he had great difficulty in securing suitable men. He finally recruited twelve and got them safely to India in September 1840. Three of them were allotted to Bombay, where they started work at Broach. In 1841-42, about 350 bighas of land were sown with New Orleans

seed which "vegetated in a most luxuriant manner, growing strong and healthy, showing abundance of blossoms, but no sooner had the first rains ceased than it became blighted and stunted, from which state it had never afterwards recovered." The planters expressed the opinion that the American cotton plant could not be cultivated so as to yield a profitable return or equal the quality and quantity of the same plant in America. They thought, however, that the quality of the indigenous cotton might be improved. So little hope, however, had they of ultimate success and so discontented were they with the terms of their engagement that they resigned their appointments and returned to America. The abandonment of the farm was at first contemplated, but, in consequence of a memorial from the Bombay Chamber of Commerce, it was decided to continue the experiments, and another of the planters, a Mr. Hawley, was transferred from Madras to Bombay. His efforts met with no better success than those of his predecessors. In 1842-43, 475 pounds or 11¼ pounds per acre was all the cotton gathered from 40 acres sown with New Orleans, Sea Island and Bourbon seed. A solitary bale of Bourbon cotton was produced in 1844. The total expenditure in Broach up to the end of the season 1843-44 was Rs. 1,21,462. The known and estimated value of the cotton grown amounted to Rs. 55,000 only, leaving a loss of Rs. 67,000 during four years, exclusive of charges for machinery from England. In 1847, the experiments were transferred to the charge of Mr. Mercer, another of the American planters, whose efforts in Dharwar will be mentioned presently. He went on leave shortly afterwards and in 1849 the Bombay Government resolved to abandon the experiments as useless. Their only result had been "to show that some kinds of exotics such as New Orleans and Bourbon yielded a small crop occasionally when cultivated as garden plants with great care and expense and that by double the care and attention and more than double the expense of the native cultivation, a larger yield and better and cleaner quality might be obtained from the indigenous cotton than the ryots can produce, but not sufficiently so to repay the additional outlay: and, finally, that the native cotton when cleaned by the American sawgin was generally injured in its staple."

The history of the failure to establish exotics in Broach is typical of that of the experiments in most other districts, and I will not weary you with details. Khandesh had the benefit of the services of two of the American planters, Mr. Blount who was transferred there from Gorakhpur in the United Provinces in 1845 and Mr. Simpson transferred from Madras shortly afterwards. The latter took over sole charge in 1846, when Mr. Blount was moved to Dharwar. The history of the twelve planters would form an interesting subject for a separate study if one had time to work it out. Mr. Simpson abandoned the idea of an experimental farm altogether and entered into contracts with ryots for the cultivation of New Orleans cotton at the rate of Rs. 5 per bigha, with remission of land tax. About this period, Mr. Elphinstone became Collector of Khandesh and took a lively interest in the extension of the cultivation of American cotton. Largely as a result of his exertions, the area under it went up to 13,619 bighas in 1851-52, but the crop was a partial failure owing to the cessation of the rains in September, and Mr. Elphinstone was compelled to admit that the experiments had not been successful. In 1854, the office of Superintendent of Experiments in Khandesh was abolished. In Surat, Ahmedabad, Kaira, Ahmednagar, Satara, Sholapur, Thana, and Ratnagiri in which district Mr. Elphinstone again made extensive trials, there is the same melancholy record of experiments undertaken and abandoned. In Belgaum, fortunes fluctuated to a greater extent, but I will not go into the matter as time is getting on and I wish to pass to the one bright spot, Dharwar. After Dr. Lush's failures, which, as I have said, later generations, with a perverted historical sense, have magnified into success, nothing was done until 1842, when Mr. A. N. Shaw, the Collector, to whom more than anyone else belongs the credit which attaches to the introduction of Dharwar American cotton, began to take an active interest in the cultivation of exotics and grew some New Orleans seed in the Hubli Taluka. Mr. Mercer, who has already been mentioned, and who had been transferred from the United Provinces to Bombay, reported most favourably on the results, though he said that the staple was not equal to that of the same description of cotton grown in America.

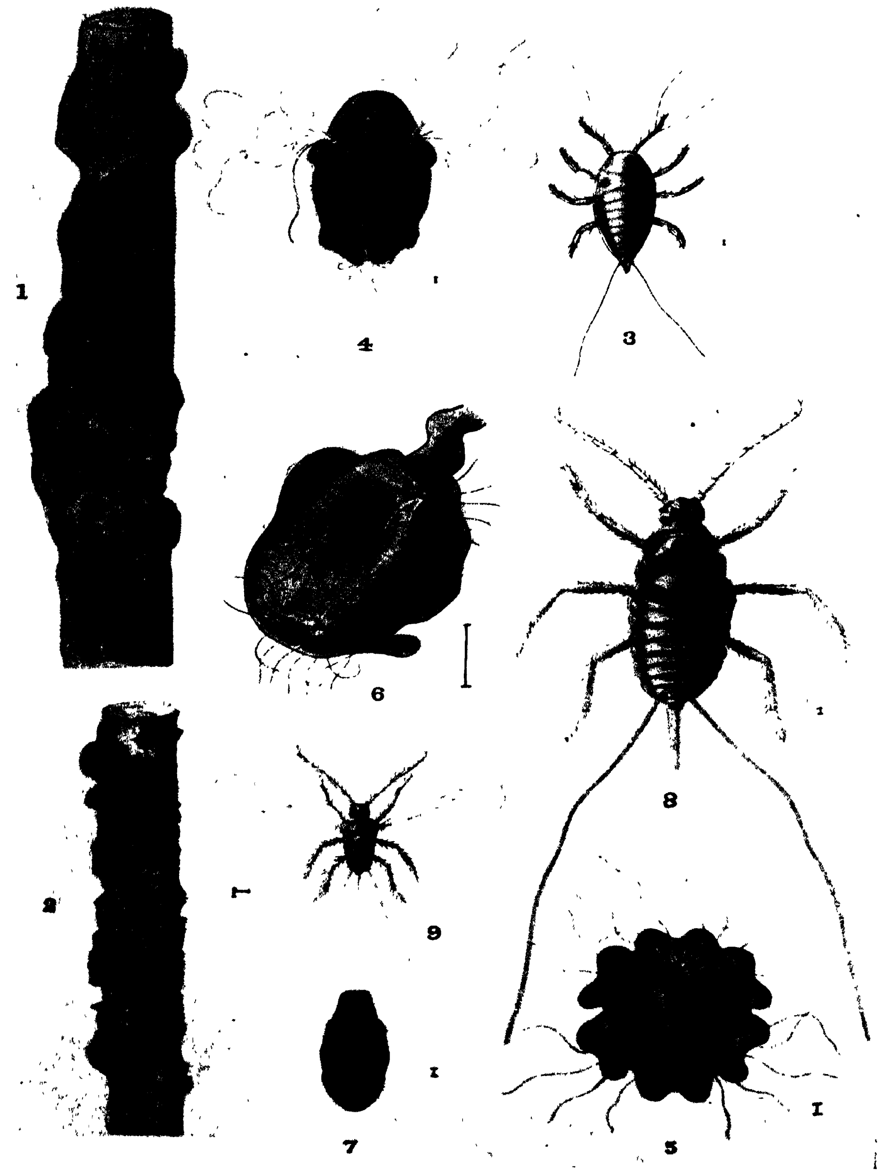
In 1843, Mr. Mercer was appointed to superintend a series of experiments in the Dharwar District and was given the assistance of Mr. Hawley, another of the planters, and of a Mr. Channing. Land was selected in Koosighul in the Hubli Taluka, and seed was supplied by Dr. Wight from Coimbatore. In June 1843, Mr. Shaw issued a circular setting forth the advantages of the exotic cotton, giving instructions as to how it should be cultivated, and guaranteeing the cultivators against loss from bad seed. Five hundred and forty-five acres were sown with exotics that year, including 183 acres of the experimental farm. Of the latter, 80 acres were planted with New Orleans and 63 with Broach. These two varieties gave the largest yields. Five sawgins were imported from Broach and Coimbatore and the whole of the farm produce was ginned by them. It was decided to confine further experiments to Broach and New Orleans. In 1844-45, the cultivation of exotics was extended to 3,749 acres. A second small experimental farm was opened at Garag and placed under the care of Mr. Hawley. Mr. Shaw left the district at the beginning of that year. At the suggestion of the Court of Directors, the Bombay Government empowered his successor, Mr. Goldsmid, to purchase from 500 to 1,000 bales of cleanly picked and carefully ginned New Orleans cotton at a price "so much above that of cotton in the state in which it is usually brought into the market as the differences of real value will justify." The Bombay Chamber of Commerce reported on the New Orleans cotton as short and weak in staple, and thought it better adapted for the China market than for export to England. The Government, however, shipped the whole produce of the ryots as well as that of the farm, about 280 bales in all, to Liverpool, where it fetched $3\frac{3}{4}d.$ a lb. against $4d.$ to $6d.$ for Surats. At the beginning of 1845 it was decided to abolish the two experimental farms, "as being cultivated precisely on the native system, they did not serve the purpose of model farms." The only deviation which had been introduced was that cotton was planted for two years running on the same land with indifferent success and it was considered that this prevented the planters from superintending the harvesting operations of the ryots. The planters

were allowed to contract with ryots for the cultivation of New Orleans cotton under their own direction. They accordingly contracted for about 836 acres at the rate of two rupees an acre in excess of the rent, the picking of the crops to be at their expense and the produce to belong to Government. The details of this arrangement are, it will be noticed, not quite as clear as they might be. In 1845-46, the cultivation of New Orleans increased to 11,176 acres. The contract system was abandoned after this one season as there had been such a rapid increase in the land under New Orleans, and Government contented itself with a virtual pledge to purchase the crop, if necessary. The total quantity purchased by Government amounted to 563 *khandis*. A little of it was sold in Bombay in conjunction with cotton from the other experimental farms in Belgaum and Khandesh at an average price of Rs. 29-8 per *khandi* above that of Surats, Kumptas, and Oomrawattees. In 1846, the cultivation increased to 22,331 acres and the produce was, in great part, bought by native merchants on their own account at Rs. 15 per *khandi* above the price of indigenous cotton. That year Mr. Hawley resigned and Mr. Mercer left Dharwar for Khandesh, being replaced by Mr. Blount. The number of sawgins in the district had by this time increased to 29. In 1848-49, the area under American cotton fell to 3,351 acres. Government ordered an enquiry which showed that the fall was largely due to the fact that the cultivators had been compelled, or regarded themselves as compelled, to cultivate New Orleans and to the difficulties in getting their produce ginned. More gins were provided in consequence, and the Collector was authorized to purchase the whole of the crop. As a result of these measures, the cultivation again increased to 15,573 acres in 1849-50, to 31,688 in 1850-51, and went on growing until it reached 178,682 acres in 1861-62. About 1858, the reputation of Dharwar American cotton fell, this being due according to Dr. Forbes—a well-known name in the history of Bombay cotton—to the adulteration and mixture of New Orleans with indigenous cotton. The difference in price between Kumpta and Dharwar, which in 1850-51 had been from 1*d*. to 1⅝*d*., had fallen in 1859 to a farthing. Dr. Forbes took steps to prevent the careless sowing of mixed American and

indigenous seed and to secure that the sawgins should be kept in good order. This resulted in a marked improvement in the quality of the cotton.

We will stop our lengthy survey of the early history of Bombay cotton at this point. With the American Civil War and the consequent appointment of Cotton Commissioners for Bombay and the Central Provinces, and subsequently one for Cotton and Commerce with the Government of India, a new era in the history of Indian cotton begins. One fact I should have mentioned was the Cotton Adulteration Regulation of 1829, which provided penalties for the fraudulent mixing of good and bad descriptions of cotton, for the adulteration of cotton with stones, earth or salt water and for exposing it at night to heavy dews. This Act did not extend to Bombay itself but, on the representation of the Bombay Chamber of Commerce, a very similar Act was passed in 1851 for the islands of Bombay and Colaba. Neither of the Acts proved very effective in practice in stopping damping and adulteration, mainly because no machinery was provided for enforcing their provisions.

As I said at the outset, you may have wondered why I have inflicted all this history upon you. But I think you will now agree that it has been useful in showing you that almost every problem which the Indian Cotton Committee is attempting to solve dates from the early years of the British connection with India. You will now be able to realize some of the difficulties which confront the Committee. You will see that from the outset England turned to India as a source of supply of cotton but never succeeded in getting what she wanted. Whether the Committee will succeed in solving the question whether better cotton can be grown in India remains to be seen. In conclusion, it will, I would suggest, be a useful task for you to discuss amongst yourselves at future meetings of the Association, why it was that the experiments with exotics in the various parts of the Presidency proved a failure, except in the case of Dharwar, why it is that it is so difficult to prevent damping and adulteration, and the various other questions which arise out of the early history of cotton in Bombay.



TACHARDIA LACCA.

EXPLANATION OF PLATE XXIII.

Fig.	1.	Healthy insects on stick.
,,	2.	Unhealthy ,, ,, ,,
,,	3	Young lac insect. × 40.
,,	4.	A female 4 weeks old. × 35.
,,	5.	,, 13 ,, × 15.
,,	6.	Young lac insects emerging from a female cell. × 4.
,,	7.	Male cell, 13 weeks old. × 12.
,,	8.	Wingless male. × 12.
,,	9.	Winged male. × 40.

THE PRESENT CONDITION OF LAC CULTIVATION IN THE PLAINS OF INDIA.

BY

C. S. MISRA, B. A.,

First Assistant to the Imperial Entomologist, Pusa.

At a time when every mind is busy with schemes of development, when every effort alike of experts and industrialists is employed on doing something to improve the general and economic condition of the poorer classes, no excuse should be needed for calling attention to an industry which is as old established as it is important. From time immemorial it has formed the means of livelihood of thousands, if not millions, of the poorer classes of India, especially the aborigines inhabiting the outskirts of forests and such other areas where the hosts of the lac insect abound. That lac is a resinous secretion produced by an insect which sucks the juice of plants and transforms it into resin which surrounds it completely may not be known to some readers of this Journal. The secretion comes out of the epidermis of the insect which on exposure hardens into a deep red or orange-coloured substance, semi-transparent and hard, breaking with crystalline fracture. The insect belongs to a group commonly known as scale insects. It is found growing spontaneously on a large number of trees [*Bulletin No. 28, Pusa Agri. Res. Inst.*, (Revised edition), page 2]. At the time of emergence the young insect is one-twenty-fifth of an inch long, deep red in colour, with three pairs of legs, a pair of feelers, a small bent tube and a pair of thin hairs at the end of the body (Plate XXIII, fig. 3). It is very sluggish in its movements and wanders about until it comes upon a suitable spot to fix itself. When once fixed it cannot be removed. After

fixation it thrusts its beak into the tissues of the stem and begins sucking the juice. The sap thus taken into the body is greatly transformed and is given out uniformly through pores all over the body in the form of resin, which after a few days encases it completely. If the young insect is a female it remains fixed once for all. If a male it emerges twice a year either as a winged or wingless little creature (Plate XXIII, figs. 8, 9), which after fertilizing the female dies. After fertilization the female develops fast. It takes in more sap, consequently exudes more resin and swells up (Plate XXIII, fig. 6). The lac-bearing branches are then cut off and placed on trees having a sufficient number of succulent branches. When the young insects have swarmed out, the old lac-bearing branches are removed, the resinous encrustation scraped off with a knife, ground in a mill, soaked in water and washed. The pure animal resin thus obtained is mixed with colophony and orpiment, cooked over a slow fire and drawn out into thin sheets—commercially known as shellac.

Within the last decade the industry has passed through various vicissitudes. It has brought ruin to more than it has benefited, and the pity is that up to the present time the causes which have brought about such a state of affairs have not been well understood. No doubt, over-production and the consequent over-stocking of the Continental and the American markets have contributed to a large extent to the lowering of the prices of the crude material from which shellac is manufactured ultimately. The prices touched their lowest point a year after the breaking out of the present war and the manufacturers as well as the cultivators in the interior of the lac-growing tracts began to think seriously of either giving up the cultivation and manufacture of shellac entirely or limiting their out-turns. In fact the prices for shellac had gone down so low—Rs. 22 a maund—that it was hardly worth while cultivating the lac. The cultivator could hardly recoup the cost of cultivation and was keenly on the look-out for something else to grow. The prices for the crude material, commercially known as stick-lac, continued to fall till July 1915, when fresh uses were found for shellac. Its export then was limited and it was declared a contraband of war. From

that date prices began to rise. Manufacturers ceased to make forward transactions and the cultivators, knowing that the prices would rise, hung on to their stocks.

There was in the phraseology of the Stock Exchange "all-round briskness." The industry seemed to have taken a new lease of life. There were enquiries for more lac all round. The manufacturer was willing to advance money on the strength of the future crop and the hitherto neglected cutltivator was the centre of attention, and he too in order to make the most of the favourable times spared no pains to collect every granule of lac wherever it could be found.

This state of affairs continued for some time, when with the steadying of prices of shellac the normal flow of the crude material again began. But in spite of all this, the actual cultivation of lac has remained as neglected as before. The experiences of 1906 and 1907 were again repeated. There was a general scramble to collect as much material as could possibly be obtained from trees large and small. Fresh and not well thought-out schemes were launched immediately and are still being continued for extending the cultivation of lac in areas where no previous cultivation has been done and where the climatic conditions which are an important factor in the development and subsequent acclimatization of the lac insect are decidedly unfavourable.

This short note has been written to draw the attention of the people who have either started the cultivation or are contemplating doing so in the future. One remarkable thing in the stimulus afforded by the present abnormal rise in prices is that a large number of persons have already either actually started cultivation or are definitely thinking of starting it in localities where success is very doubtful, and that fewer attempts have been made in localities which at present practically meet three-fourths of the demand of the world.

During the past fourteen years I have been watching closely the trend of events, and I think it is much better to concentrate attention on improving the local methods of

cultivation and storage in localities where the industry has been in existence for centuries rather than to start cultivation in localities where success is doubtful and where the moral effect of the failures is bound to act as a set-back to the budding industrialist.

As has already been stated by me in a note put before the President of the Indian Industrial Commission when he visited Pusa in November 1916, India is the only country in the world which supplies the market with shellac in its various manufactured forms, and in consequence the usual efforts have been and are being made by other countries to capture this monopoly. For the last few years the Japanese have been trying to grow lac in Formosa on *Schleichera trijuga* which abounds in the island and *kusumb** brood-lac was despatched from Pusa in crates especially made for the purpose. The plants were first potted in wooden boxes of special design to facilitate transport and, when these were established, they were inoculated with *kusumb* brood-lac and sent down to Calcutta in charge of a fieldman two months ahead of the swarming of the young lac insects. The Germans tried to experiment with lac cultivation at Amani in German East Africa. For this purpose Dr. Morstaadt took a small consignment of *ber* † brood-lac when he visited this Institute nine years ago. Some *Zizyphus jujuba* brood-lac was also taken by Dr. L. H. Gough, Entomologist, Department of Agriculture, Egypt, when he visited Pusa in 1912 in connection with the introduction of Cotton Bollworms (*Earias fabia* and *Earias insulana*) parasites into Egypt. But so far nothing is known definitely as regards the success or otherwise of these experiments. It is therefore all the more necessary to put the industry on a sound basis by organizing the cultivation on scientific lines and in consonance with the present market requirements, and to eliminate such factors as introduce an element of uncertainty into the whole business.

In years when the prices rise, as was the case from 1905 to 1907 and again during 1915 and 1916, attempts are made to oust the natural product from the market with a synthetic material. But

* *Schleichera trijuga*. † *Zizyphus jujuba*.

the attempts prove abortive, as the constituents of the synthetic product either cannot be obtained in bulk or the cost of manufacturing it leaves very little margin of profit to the manufacturer wherewith to push on its sale and to popularize it among the consumers of the natural product. These are some of the factors which militate against the production of the synthetic product on a commercial scale. In the country itself the short-sighted manufacturers, eager to take full advantage of the temporary rise in prices, adulterate the natural product. In fact, during years of inflated prices, the proportion of the natural product—commercially known as seed-lac—in the manufactured samples of shellac is so low that it requires great care and judgment to discriminate the pure from the adulterated product. It therefore behoves every manufacturer of shellac to stop adulteration and concentrate on the manufacture of a standard article which will be of such excellence as to effectually debar the synthetic product from competing.

A few years ago we tried to find out the reason of the partiality shown by the consumers for shellac, which even in its standard form is more or less adulterated with foreign ingredients such as colophony and orpiment, over seed-lac which is a pure animal product and in which the impurities can be easily detected. With this object in view samples of stick-lac produced at Pusa were ground in a hand mill to a standard size of grain. These were then soaked and washed with water—as per details given in *Bulletin No. 28, Agricultural Research Institute, Pusa,* (Revised edition), page 20. But before the last washing was given Monohydrated Sodium Carbonate at the rate of 8 oz. to a maund (80 lb.) was added. The alkali was mixed thoroughly with the hand in the churning vats and when the desired softness was felt water was added and strained through wire-gauze sieves of graded meshes. The washed material was aerated in the shade and was frequently turned over to dehydrate it completely. This was repeated daily until the resultant product was a beautiful pale brown in colour considerably superior to the seed-lac obtained without the addition of the alkali. The treated samples were sent to Messrs. Parsons & Keith, London,

and their report on the samples sent is quoted below *in extenso* :—

			Remarks
Kusumb (*Schleichera trijuga*)	Untreated ..	45s. per cwt. =Rs. 24-11-3 a md. (82 lb.)	Good quality, only a limited sale.
	Treated ...	85s. per cwt. =Rs. 46-10 9 a md. (82 lb.)	Very fine, bold clean seed-lac. We have not seen any as good as this before here. There would be a good ready sale if the price could compete with fine orange shellac and Karachi seed-lac. In Karachi there is a fairly large business done, but this quality would be preferred by buyers.
Palas (*Butea frondosa*)	Untreated .	35s per cwt. = Rs. 19-3-6 per md.	Small stick-lac, not very saleable.
	Treated .	75s. per cwt. =Rs. 41-2-11 per md.	Good quality, pale seed-lac, rather small. The same remarks apply to this.

* * * * * * * * * *

"Before speaking with absolute certainty, we shall have to test the samples marked 'treated' to see that they are saleable, but judged by their appearance buyers seem to be taken with the treated samples, especially the Kusumb. This class of lac has only been shipped here in small quantities so far from Mirzapore, and it occasionally fetches a high price for special purposes. To be sold in large quantities it would have to compete with shellac and the price would vary with the price of shellac.

"We believe the treated would meet with a ready market and would fetch, roughly speaking, double the price of the untreated. Based on the present price of shellac, we think you could safely reckon to sell the Kusumb treated in quantity at 85*s*. per cwt., and the Palas treated at 75*s*. per cwt. We should recommend a trial shipment of 20 to 25 bags of each quality."

From further trials made at Pusa it was found that if a larger quantity of Monohydrated Sodium Carbonate than that stated above was added or if the alkali was allowed to remain in contact with the animal resin for more than 5 to 10 minutes, the natural wax surrounding the grain of lac was washed away and the resultant product was rather rough and crisp to the feel. From figures obtained through the courtesy of Messrs. Moran & Co., Brokers,

Calcutta, the total quantity of shellac exported from Calcutta during the past twelve years, 1905—1916, was :—

	Cases	Weight in maunds (80 lb.)	Price per md.			Total value		
			Rs.	A.	P.	Rs.	A.	P.
1905	157,536	339,840	87	0	0	32,264,080	0	0
1906	156,502	391,255	107	0	0	41,864,285	0	0
1907	206,789	516,972	102	0	0	52,731,144	0	0
1908	222,112	555,280	57	8	0	31,928,600	0	0
1909	322,006	805,015	37	8	0	30,188,062	8	0
1910	289,996	724,990	40	8	0	29,362,095	0	0
1911	235,339	588,347	37	0	0	21,768,839	0	0
1912	254,141	635,352	34	0	0	21,919,644	0	0
1913	191,993	479,982	46	0	0	22,062,842	0	0
1914	231,831	579,627	35	8	0	20,576,658	8	0
1915	243,502	608,755	34	0	0	20,697,670	0	0
1916	236,681	591,702	55	0	0	32,543,610	0	0
		6,817,117				357,907,530	0	0

Thus on an average over five and a half lakhs of maunds of shellac worth about three crores of rupees have been sent out yearly from the port of Calcutta alone. Had similar figures been obtainable for the ports of Bombay and Karachi it would have been found that over seven lakhs of maunds of shellac, worth over four crores of rupees, must have been exported from the country annually. Had this quantity been treated as already described above, there would have been a net saving of thirty to thirty-five lakhs of rupees, besides yielding a large quantity of lac-dye which might have been standardized to a paste to facilitate transport and to yield a colouring matter which, with proper mordants, might have produced from light to fast colours.

At the present time when the prices of shellac are oscillating to such an extent, with a general tendency to rise, as will be seen from the weekly quotations taken from Messrs. Moran & Co.'s weekly shellac reports,* it would be worth while sending trial

*	T. N.	Superfine
9th January, 1918	92	120
16th „ „	91-92	120
23rd „ „	92-92/8	120
30th „ „	93-96	120
6th February „	93-96	120
13th „ „	93-96	120
20th „ „	97-98	125
27th „ „	97-99	125
6th March „	97-99	125
13th „ „	99-101	125
20th „ „	100-102	125

shipments of seed-lac treated as noted above. In the beginning the new brand may be expected to meet with some opposition, as trade prejudices, however peculiarly they might have become grafted in practice, die hard; but if the quality of the new brand be maintained at a uniform standard, it is expected that the consumers would gradually take to it and would give up the use of the shellac in its present adulterated forms. This change would do away with the necessity of storing stick-lac in bulk and thus allowing it to get " blocky " or " coagulated." And this is not a small item as every manufacturer would testify from his bitter personal experience as to the cost of storing the stick-lac in bulk and preventing it from getting spoiled by insects which feed exclusively on the stored material irrespective of those which spoil the produce on the trees. No doubt, with a little attention to details, this loss can be prevented easily by clearing the godowns annually and fumigating them either with carbon bisulphide (vide *Bulletin No. 28, Agricultural Research Institute, Pusa,* Appendix C) or with flowers of sulphur at the rate of 4 lb. per 1,000 cft. of space. Before fumigating, the godowns should be cleaned thoroughly and no stray lumps of worm-eaten blocky-lac should be allowed to lie about the interior. All old burrows, pits in the floor, and crevices in the walls should be plastered over and the doors and the windows made airtight as far as possible. The weighed quantity of sulphur should then be placed in the rooms in earthen pans containing water to catch the overflow and the mass ignited. Doors and windows should then be closed and allowed to remain so for 24 hours, when they may be opened to let in fresh air.

In order that a sufficient quantity of stick-lac should be readily available in the market, it will be necessary to improve the methods of cultivation practised in the different parts of the country. Prior to 1908 when lac-dye was a marketable item of considerable importance it paid the cultivator as well as the manufacturer to pay for stick-lac which was rich in colouring matter. But now with the introduction and extensive use of aniline and other dyes, lac-dye has sunk into insignificance and is not of much commercial

importance. With this change in the market the cultivator has not kept himself in touch. He still follows the old antiquated system of removing lac before swarming has taken place. This, though it does not directly benefit him now, is at the bottom of the shortage in the supply of the crude material, and in spite of the prolific growth of the lac insect it has not been able to hold its own against the increase of parasites, predators, and other factors which restrict its growth. It is therefore but proper that steps should be taken to remedy these defects and to bring home to the cultivator that it no longer pays either him or the manufacturer to collect lac rich in colouring matter. This can be avoided easily by removing all the lac from the trees a fortnight before the swarming takes place and putting it on trees already pruned for the purpose. The *ber* and the *palas* * stand pruning well and with judicious and seasonable pruning their life and vitality could be increased considerably—the prunings may be utilized either for charcoal making or for fencing cattle enclosures. Our experience for the past fourteen years shows that the produce from pruned trees is richer in resinous contents than that obtained from unpruned trees and that the successive broods reared on pruned trees are not so liable to disease as is otherwise the case. The present is a very opportune time to bring about these changes in the methods of cultivation, as with the high prices prevailing for shellac and in proportion for stick-lac for the last three years the cultivator has been able to recoup the losses sustained prior to 1915 and can well afford to spend a fair portion of his profits in renovating the trees either by pruning them or by making fresh plantations divided into blocks for the yearly and systematic production of lac. Besides this, he should also see that only healthy brood-lac is brought and put on the trees. This he can do easily by consulting the Plates XIII and XIV, in *Bulletin No. 28, Agricultural Research Institute, Pusa* (English and Hindi editions). He should also avoid bringing or purchasing brood-lac from localities where parasites and predators are present in large numbers and thereby running the risk

* *Butea frondosa.*

of introducing them into new localities. Once these are established it is not only difficult but also expensive to eradicate them effectually. He should also arrange for occasional exchanges. Brood-lac from hilly tracts is more vigorous than that grown in the plains from year to year. While purchasing he should also see that the brood-lac which he wishes to put on his trees is obtained from a locality or localities where the climatic conditions are as similar as possible to those obtaining in his place. It is no good obtaining brood-lac from the borders of Nepal and experimenting with it at Allahabad or Gwalior. Such trials are bound to end in failure, and should as far as possible be avoided. Further, it is much better to use *palas* brood-lac on *palas*, *ber* on *ber*, *kusumb* on *kusumb*, and brood-lac from Ficus species on Ficus species. Though *kusumb* brood-lac is the hardest of all, yet from further observations it has been found that it is from business considerations safer to abide by the amended note given above.

At present the distribution of lac cultivation in India is practically as shown in the map. In Sind the lac insect flourishes best on the *babul* (*Acacia arabica*), and over three-fourths of the quantity collected and exported from Karachi is obtained from this source. *Palas* lac is mostly obtained in parts of the United Provinces, Bihar and Orissa including Mourbhanj, Central India, Rewah, Nagode, and Maihar, the northern and the south-eastern parts of the Central Provinces, some parts of Bengal and Bombay—Panch Mahals, Ali Rajpur and Deogad. *Ber* lac grows spontaneously in the Punjab and is cultivated at Rungpur, Murshidabad and Dumkah in Bengal, and Manbhum in Bihar and Orissa. *Kusumb* lac is obtained in bulk from the Chota Nagpur Plateau and the Chhattisgarh Division in the Central Provinces, though it is more or less collected in almost all the lac-producing tracts in India. Large quantities of lac on Ficus species are obtained from Assam, where it is also grown in the Garo and the Khasi Hills on *mirimah*—a variety of *tur* (*Cajanus indicus*).

With such diversity in the foodplants of the lac insect, much difficulty has been experienced in the past in obtaining healthy

brood-lac at proper times for starting cultivations or making trials as regards the suitability or otherwise of the lac insect in new localities. The cultivators have hitherto neglected this source of income. The prices for the brood-lac and the subsequent transport charges have been so exorbitant in the past that it has not paid at all to start cultivation in new localities. If, however, suitable distributing centres are established in favourable localities, new areas—hitherto of no economic use to their owners—will be tapped yielding large and fairly constant quantities of stick-lac which will have the effect of steadying the prices of shellac if other factors remain normal. By the establishment of such nurseries vast areas overrun with *palas*, especially in the United Provinces, Central India, the Central Provinces, and Bihar and Orissa, will become productive and will benefit directly the rural population of such areas. For the present the establishment of a dozen nurseries distributed as follows would be ample :—

Sind	**2 nurseries.**	**For the supply of *babul* brood-lac.**
Central India	**2 ,,**	**For the supply of *palas* and *kusumb* brood lac.**
Bombay	**1 nursery.**	
C. P. and Berar	**2 nurseries.**	
Bihar and Orissa	**2 ,,**	
United Provinces	**2 ,,**	
Bengal	**1 nursery.**	**For *ber* brood-lac.**

By some such arrangement the difficulties of transport would be considerably lessened, and the growers would have the assurance of obtaining healthy brood-lac at the proper time and at reasonable prices.

RECENT INVESTIGATIONS ON SOIL-AERATION.*

PART I. WITH SPECIAL REFERENCE TO AGRICULTURE.

BY

ALBERT HOWARD, C.I.E., M.A., A.R.C.S., F.L.S.,

Imperial Economic Botanist.

I. INTRODUCTION.

THE growing of a crop is an exercise in applied physiology. This operation, as is well known, is only possible through the simultaneous operation of a number of soil factors—water, mineral salts, temperature and oxygen. What is not always fully realized is that if any one of the factors concerned, for example, the supply of combined nitrogen, is in defect, growth is checked and stops altogether when this substance is no longer available. Nitrogen is then said to be a limiting factor in growth. On the addition of a further supply of this substance, growth at once re-commences and proceeds till the crop is ripe unless some other factor becomes deficient. A crop, limited in growth by a deficiency in the supply of any particular factor, is not influenced by the increase of other factors. Thus a shortage of combined nitrogen is not made up for by the application of phosphates or potash or by increased irrigation. Just as the strength of a chain is limited by that of its weakest link, so the growth of a crop depends on the factor in greatest defect.[1] The chief object in soil-management is the removal, in advance, of any possible limiting factor which may operate adversely.

The aeration of the soil is a factor in growth which has been greatly neglected in the past. The three substances involved—oxygen, nitrogen, and carbon dioxide—are gases which are invisible and are not on the market in the form of artificial manures like nitrate of soda or superphosphate of lime. Only very indirectly has soil-aeration been recognized in the European literature on agriculture

* A lecture delivered to the Indian Science Congress on 9th January 1918.

[1] In the case of the temperature factor, growth is also limited when the optimum is exceeded.

in the importance attached to a proper soil texture. Soil texture is really important because of its influence on soil-aeration. In this lecture it is proposed to refer to some of the recent work on soil-aeration and to indicate the direction in which further investigation is needed particularly in the irrigated tracts of India.

II. Aeration and the Amount of Growth.

If growth is influenced by the aeration of the soil, the effect of this factor should be apparent in any series of cultures where all the conditions are uniform except the ventilation of the roots. A number of investigations have recently been carried out on this point from which the following examples are taken.

1. *The effect of increased aeration on the root development of barley.* This matter is dealt with in one of Mr. Hall's papers in the *Philosophical Transactions* (B, vol. 204, 1913). One example taken from this paper will suffice.

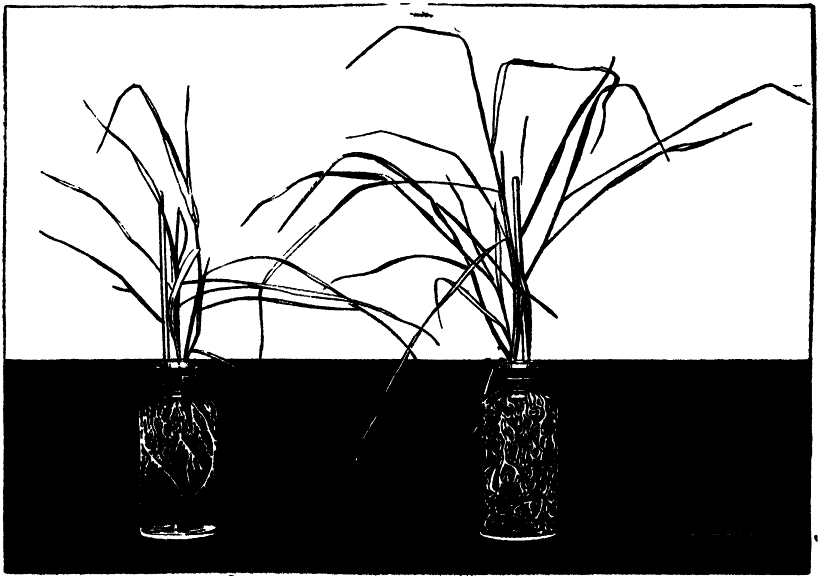


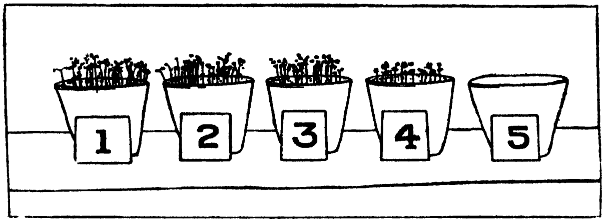
Fig. 1. Growth of barley in solutions aerated once a day (left) and aerated continuously (right).

On the screen are represented two water cultures of barley (Fig. 1). The bottle on the left was aerated once a day, that on

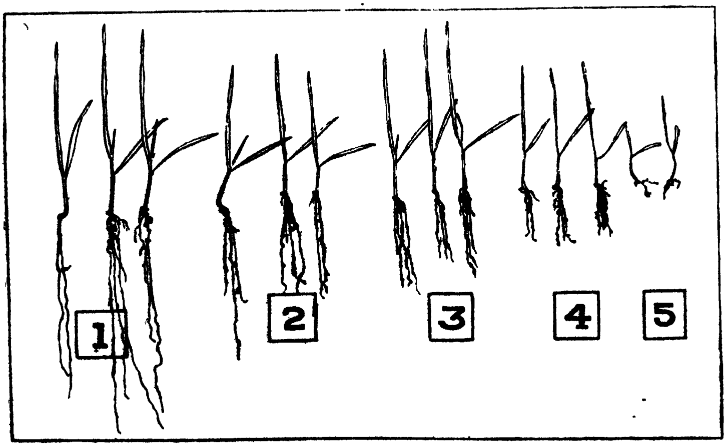
the right was aerated continuously. It is clear that both root development and growth depend on the amount of aeration.

2. *The effect of soil texture on growth.* The results published by Mr. Hunter in Vol. IV of the *Proceedings of the Philosophical Society of the University of Durham* show the marked effect of soil texture on growth. Various kinds of soil were used and the plants selected were sunflower, peas, wheat, and cress. Five degrees of soil texture were adopted as follows :—

1. Soil in small lumps, loose.
2. Soil fine, loose.
3. ,, ,, firm below, with a loose surface.
4. ,, ,, firm.
5. ,, ,, hard.



SEEDLINGS OF LEPIDIUM SATIVUM.

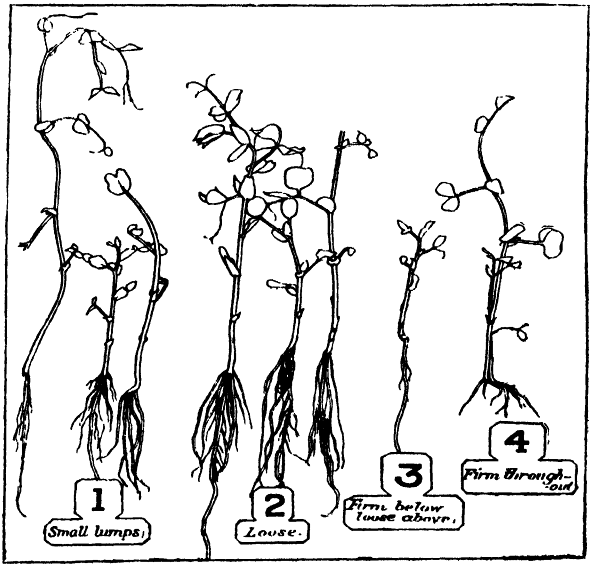


WHEAT PLANTS

Fig. 2. The effect of soil texture on the growth of cress and wheat.

The results obtained are shown on the two following slides (Figs. 2 and 3).

The first (Fig. 2) shows the effect of soil texture on the growth of cress and wheat. Where the soil was hard, the cress seeds did not germinate. In the case of wheat, the effect of the texture on root development is very clear. The closer the packing, the poorer the growth. The corresponding results with peas are shown on the next slide (Fig. 3).



PISUM SATIVUM.

Fig. 3. The effect of soil texture on the growth of peas.

Here the best growth was obtained where the soil was fine and loosely packed. Mr. Hunter next measured the effect of soil texture on the resistance to an artificial air current. It was found that the resistance of columns of soil was in accordance with their textures. The results are to be seen in the table on the screen (Table I).

TABLE I.

Soil texture and air movement.

Description of soil	Height in cm.	Resistance offered
1. Small lumps, loose	35	1 unit
2. Fine, loose	35	2 units
3. Fine, firm below with loose surface	5 loose 30 firm	17 ,,
4. Fine, firm throughout	35	42 ,,
5. Fine, hard throughout	35	310 ,,

3. *The effect of adding potsherds or sand to the Pusa soil.*[1] The soil at Pusa is a calcareous silt which readily forms a surface crust and often loses its texture altogether after long continued heavy rain. The addition of one inch of potsherds to the heavy soils of the Botanical area increases the yield considerably. Some of the results obtained are given in Table II.

TABLE II.

The effect of diluting Pusa soil with potsherds or sand.

1. Wheat, oats, and tobacco.

Crop	Yield per acre of control plot		Yield per acre with one inch of potsherds		Increase per acre		Percentage increase
	m.	s.	m.	s.	m.	s.	
Oats	24	17	28	36	4	19	18
Wheat	16	18	19	30	3	12	20
Tobacco	21	0	23	3	2	3	10

2. Indigo.

Kind of soil	No. of plants measured	Average length in cm.	Percentage increase
Soil only	33	36·7	0
50% Soil + 50% sand	36	51·6	40
90% Soil + 10% potsherds	33	48·3	31
70% Soil + 30% potsherds	35	50·9	38

These examples, selected from many others, are sufficient to illustrate the main fact that soil-aeration is one of the factors on which the growth of plants depends.

[1] Howard, A. *Bulletin 61, Agr. Res. Inst., Pusa*, 1916.

The structure of the soil.

To follow the subject further, it is necessary to consider the structure of the soil and the relation of this structure to the root system of the plant. The soil consists of particles with intervening spaces between them known collectively as the pore space. For every soil, the proportion of the volume of this pore space to the total volume of the soil varies with the closeness of packing. When the soil texture is good, the pore space is large. After heavy rains and when waterlogged, fine silt-like soils run together into a condition of close packing when the pore space is considerably reduced. Thus the volume of the pore space varies according to circumstances. The pore space is taken up by two things—water and air. The water occurs in thin films round the soil particles, while the soil air fills up the rest of the pore space. The next slide (Fig. 4) represents the structure of the soil, in relation to the root-hairs of a crop.

Fig. 4. The soil in relation to the root-hairs of a plant. The solid soil particles are darkly shaded, the air spaces are white, the adherent water is indicated by concentric lines. From the piliferous layer of the root two root-hairs arise. (After Sachs.)

In the water films round the particles there is intense biological activity. New root-hairs are constantly being produced by the plant, which, for a time, absorb water and dissolved materials and then die. Various soil bacteria are occupied in the decomposition

of organic matter. Both these activities involve the process of respiration. The working protoplasm in each case uses up oxygen, and carbon dioxide is produced as a by-product. The soil atmosphere is therefore constantly being called upon to supply oxygen for respiration and receives fresh supplies of carbon dioxide. Efficient ventilation is clearly essential if the air in the pore spaces is to be kept fresh. Supplies of oxygen must pass into the soil

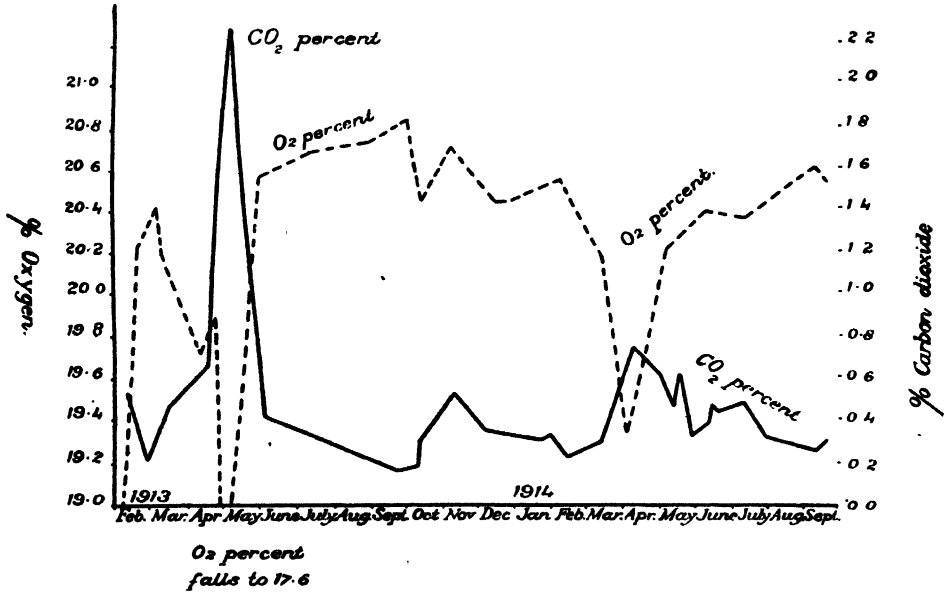


Fig. 5. Curves showing percentages of CO_2 and of O_2 in soil air in Broadbalk dunged plot.

from the atmosphere and at the same time the excess carbon dioxide in the pore spaces must diffuse out in the reverse direction. The pore spaces are the living rooms of a vast underground city the inhabitants of which require fresh air.

It is only very recently that investigators have begun the systematic study of the soil atmosphere in relation to the biological activities proceeding in the soil. Important and interesting results

are being obtained at Dehra Dun by Messrs. Hole and Puran Singh, and at Rothamsted by Dr. Russell and his colleagues, some of which have been published. In general, Dr. Russell and Mr. Appleyard[1] find that the oxygen and carbon dioxide curves are reciprocal—the oxygen falls as the carbon dioxide rises. The agreement is sufficiently close to justify the assumption that the oxygen is mainly used up in producing carbon dioxide. One of these curves is shown in the next slide (Fig. 5).

These investigations also throw considerable light on the composition of the gases dissolved in the water films. These contain very little oxygen but a great deal of carbon dioxide as will be evident from the figures in the next slide (Table III)

TABLE III.

Composition of gas held absorbed by soil. Percentage by volume.

	Weight of soil used, grm.	Percentage of moisture	Approximate volume of gas removed in successive extractions	Percentage composition of gas		
				CO_2	O_2	N_2
Pasture soil	352	28	1st 30 c.c.	52·0	0·7	47·3
			2nd 30	84·8	0·2	15·0
			3rd 22	99·1	0·2	0·7
Soil covered with vegetation .. (Broadbalk wilderness)	400	22	1st 30 c.c.	19·3	5·5	75·2
			2nd 30	57·0	2·6	40·4
			3rd 15	98·7	0·2	1·1
Rich garden soil	468	20	1st 30 c.c.	89·5	0·2	10·3
			2nd 30	99·3	0·0	0·7
			3rd 15	94·4	0·0	5·6
	extracted later		4th 30	96·8	0·0	3·1
			5th 30	92·3	0·0	7·6
Arable soil Broadbalk dunged plot.	.	24	1st 30 c.c.	10·8	4·4	84·8
			2nd 30	57·9	1·8	40·3
			3rd 15	98·4	0·0	1·6
Broadbalk unmanured ...	497	16	1st 30 c.c.	6·3	15·1	78·6
			2nd 25	40·2	9·7	50·1

The essential point is that the water films are exceedingly poor in oxygen but very rich in carbon dioxide. As they are the seat of an intense biological activity for which oxygen is essential, it is clear that the consumption of oxygen in the film is equal to the rate at which it is renewed. The details relating to the gaseous exchanges between the pore spaces and the water films need much more investigation and a further contribution has been promised

[1] Russell, E. J., and Appleyard, A. *Jour. of Agr. Sc.*, VII, p. 1, 1915.

by Dr. Russell. On physical grounds, we should expect that the water films would derive their supplies of fresh oxygen from the air in the pore spaces. The Rothamsted experiments, however, have drawn attention to another source, namely, the oxygen dissolved in the rain water[1]. Rain was found in most cases to be a saturated solution of oxygen which stimulated markedly the biological activities in the soil. The effect of showers of rain was found to be greater than that produced by water alone and could be explained by the influence of the dissolved oxygen in replenishing the supply of this substance in the water films. That rain benefits crops has long been known and practical men have always felt that something more than a moisture effect is concerned. We realize now that rainfall supplies not only water but also oxygen in the most effective form. In future, we must think of the Indian monsoon not as the distribution of so much rainfall over certain areas but rather of so much water rich in dissolved oxygen.

It will now be clear that one of the essentials for the growth of plants is the maintenance of the oxygen supply of the pore spaces and of the water films round the soil particles. The soil must be kept ventilated or the denizens of our underground city will languish for want of air. Let us study the ventilation of our underground city in connection with flood irrigation as practised by the cultivators all over Northern India. The soil is alluvial in nature. Its texture deteriorates if it is flooded with water. As it dries under the hot sun, the surface bakes into a crust largely impermeable to air. That the crust is impermeable can be seen by immersing in water a portion of the hardened surface soil after irrigation. The air escapes sideways not through the surface skin. Each successive irrigation destroys the soil texture still more and the surface crust becomes more and more impermeable to air. The effect of irrigation on alluvial soil therefore interferes with its ventilation. The process removes one limiting factor, the want of water, but it introduces another, namely, the need of aeration. That this is so will be clear from Table IV which contains the result of a recent experiment at Quetta.

[1] Richards, E. H. *Jour. of Agr. Sc.*, VIII, p. 331, 1917.

TABLE IV.

The introduction of a new limiting factor after irrigation.

Number of waterings	Area in acres	Total weight of produce	Total weight of grain		Yield of grain per acre		Percentage reduction
		lb.	m.	s.	m.	s.	
One	3·99	10,367	52	6	13	2	0
Three	2·65	6,620	25	15	9	23	26

Here the last two irrigations reduced the yield through the introduction of another limiting factor—the need of soil-aeration. Clearly if we could work out a practicable compromise between the needs of the soil for water and for air under irrigated conditions, an immediate advance in agriculture would result. This has recently been accomplished at the Quetta Experiment Station. I propose to indicate briefly the manner in which it was done. The Quetta valley is typical of the upland valleys of Baluchistan. The soil resembles that of the plains of India and the characteristic of the climate is the dryness of the air and the amount of air movement. It is a dry, windy place. Irrigated crops therefore require an enormous quantity of water. Irrigated wheat is often watered six times and the crop shows all the symptoms of poor soil-aeration—excessive liability to rust attacks, slowness in ripening, and shrivelled grain of poor quality. The irrigated wheat dries up rather than ripens and the bright straw and shining chaff which are so characteristic of this crop are not developed in the Quetta valley. It was obvious that enormous quantities of valuable irrigation water were being thrown away to no purpose on the wheat crop. A method of growing the crop on a single irrigation was worked out which is now being taken up by the cultivators. The method consists in making full use of the preliminary irrigation before sowing and the breaking up of rain crusts afterwards. The details of the method are to be found in the bulletins[1] issued by the Quetta Experiment Station. Under the new method, the yields are often higher with one irrigation than with six or seven. Harvest is about a month

[1] Howard, A., and Howard, G. L. C. *Bulletins 4 and 7, Fruit Experiment Station, Quetta,* 1915 and 1917.

earlier and the wheat ripens normally and develops the characteristic colour of the chaff and straw.

As the wheat crop on the Canal Colonies of the Punjab also exhibits definite signs of want of soil-aeration during the ripening period, I ventured to predict that at least one-third of the irrigation water now used on this crop is wasted. The matter was put to the test of experiment during the wheat season of 1916-17. The Punjab results are given in Table V.[1]

TABLE V.

Results of water-saving experiments on wheat (Pusa 12), at Gungapur, Haripur, and Sargodha in 1916-17.

Station	No. of irrigations including the preliminary watering	Yield per acre				Average yield per acre			
		Grain		*Bhusa*		Grain		*Bhusa*	
		m.	s.	m.	s.	m.	s.	m.	s.
Gungapur ...	One	12	19½	20	10	9	34	21	17
Haripur ..	,,	8	31	19	14				
Sargodha	,,	8	12½	25	27½				
Gungapur ...	Two	18	0	25	8	16	11	25	5
Haripur ...	,,	15	21	23	16				
Sargodha ...	,,	15	12½	26	32½				
Gungapur ...	Three	14	25	18	0	15	11	22	2
Haripur ...	,,	16	8	26	4				

An inspection of the figures shows very clearly that after the second irrigation water ceased to be a limiting factor and then began to depress the yield. Similar but still more striking results were obtained by Mr. Main at Mirpurkhas in Sind. The significance of these results will be apparent when it is remembered that the annual revenue derived from irrigation works in India is about £5,000,000 sterling. Taking the Indian Empire as a whole, there can be no question that the water wasted every year would, if used to the best advantage, bring in a very large direct and indirect revenue to the State.

[1] Annual Report of the Imperial Economic Botanists, 1916-17. *Scientific Reports of the Pusa Agr. Res. Inst.*, 1916-17.

III. Soil-Aeration and Quality.

The quality of vegetable products, as is well known, varies greatly with the locality. The quality of the wines of Champagne and of the tobacco grown on certain soils in Cuba depends to a great extent on the soil of these tracts. The transference of the vines of Champagne or of the tobacco plants of Cuba to other places does not mean the transfer of the special qualities associated with the wine and cigars produced in these localities.

What are the factors on which quality depends ? The breed or variety is certainly one. A rough, short-stapled cotton, for example, can never be transformed by alteration in the environment so as to resemble the best Egyptian or Sea Island types. Such a cotton can be improved to a limited extent but the fibres will always remain coarse and short. It is suggested that besides the variety, quality also depends on another factor, namely, adequate soil-aeration. Many examples can be quoted in support of this view. It will be sufficient to mention the following :—

1. *Barley.* The barley crop is grown all over England, the best samples being used for making malt. For the best beer, the barley grain must be well filled with starch so as to produce a rich, clear malt-extract. Such barleys are always grown on light land where the natural aeration of the soil is good and where the crop ripens off quickly. On stiffer soils, the aeration is bad, the barley ripens slowly and the grains are often poorly filled with starch. Maltsters do not like these barleys as they give a thin, cloudy extract.

2. *Tobacco.* As is well known, the internal tobacco trade of India is enormous. Certain tracts such as the Parganah Saraisa in Tirhut, Jais in the District of Rae-Bareli, and the Mustung valley in Baluchistan have achieved a reputation for quality which is well known in the trade. In all these places, the soils which produce the best qualities are those in which the aeration is much above the average.

3. *Cotton.* Recent investigations in the Central Provinces indicate that soil-aeration is one of the factors on which the staple

of cotton depends. Mr. Clouston has shown that on the open laterite plains near Raipur where the soil is such that its texture cannot be destroyed by heavy rain or surface flooding, long staple cotton of high quality can be produced. Further, the fibre of coarse cotton like *roseum* is improved when this type is grown on these laterite soils. Similar results are obtained with other crops like groundnuts and sugarcane.

No scientific explanation of the part played by soil-aeration in the development of quality has yet been put forward. The recent Rothamsted results however appear to throw light on this point.[1] If we compare the carbon dioxide in the soil atmosphere from cropped and uncropped land, two marked differences disclose themselves. The curves are to be seen on the last slide (Fig. 6).

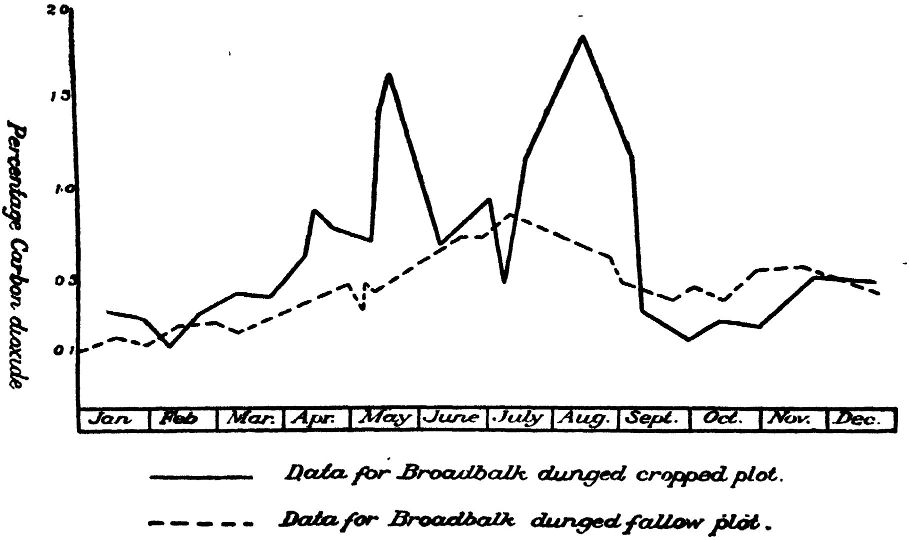


Fig. 6. Percentage of carbon dioxide in the soil air of dunged fallow and of dunged crop land.

During the rapid growth of the wheat crop in May and during the whole of the ripening period in August there is a great outpouring of carbon dioxide. This is produced at the expense of the oxygen

[1] Russell, E. J., and Appleyard, A. *Jour. of Agr. Sc.*, VIII, p. 385, 1917.

in the soil air. It is easy to understand the great production of carbon dioxide in May. This is associated with the intense biological activity in progress in the soil at this period. It is not so easy to understand why so much oxygen is required during ripening and why so much carbon dioxide is produced. In India experience teaches us that crops never ripen properly if the soil-aeration is interfered with during this period. A part of the explanation is probably to be found in the fact that the fine roots begin to die and decay after the flowering period, but this does not explain why the crop will not ripen unless air is supplied. The changes in the soil air during the life of the crop have so far not been investigated in India. A splendid field of applied research lies untouched which is bound to yield a rich harvest of results.

IV. Some other Aspects of Soil-Aeration.

It follows that if soil-aeration is a growth factor, aeration must influence the distribution of plants[1] and prove to be of importance in ecological studies. Attention is now being paid to this aspect of the subject and results are beginning to appear. In the United States, Professor Cannon of the Desert Laboratory in Arizona and Professor Free of the Johns Hopkins University find that an inhibition of root growth is caused in numerous plants by a decreased amount of oxygen in the soil atmosphere.[2] The poor conditions of soil-aeration are correlated with the absence of vegetation in the dry lakes of desert basins and the zonation of vegetation around these basins is possibly in correlation with the different soil-aeration requirements of the plants involved. Professor Cannon intends to visit India and to pursue his studies in this country.

In India also, Mr. Hole has shown that soil-aeration is an important factor influencing the distribution of woodlands and grasslands. As regards the general importance of soil-aeration in Indian forestry, Mr. Hole has kindly promised to place his views before the Congress.

[1] The distribution of gram in India is correlated with soil-aeration. See *Agr Jour. of India*, Special Indian Science Congress Number, p. 20, 1917

[2] Cannon, W. A., and Free, E. E. *Jour. of Ecology*, V, p. 127, 1917.

PART II. WITH SPECIAL REFERENCE TO FORESTRY.

BY

R. S. HOLE, F.C.H., F.L.S., F.E.S.,

Forest Botanist, Dehra Dun.

MR. HOWARD has just emphasized the importance of soil-aeration in Indian agriculture, and I hope to convince you that it is no less important in Indian forestry.

As we frequently have great difficulty in quickly establishing a vigorous growth of seedlings in our valuable *sal* (*Shorea robusta*) forests, a study of the factors influencing germination and the development of seedlings was commenced at Dehra Dun in 1909. Preliminary pot experiments carried out in 1909-10 showed that, whereas it was practically impossible to injure *sal* seed or seedlings by watering in sand into and through which water percolated rapidly, germination could be materially reduced and the seedlings rapidly rendered unhealthy in water-retaining loam and leaf-mould by keeping the soil constantly moist. It was immaterial whether this moist condition was produced by the addition of water to the soil or by diminishing the loss of water from the soil through evaporation or percolation. The injurious action was most severe in the leaf-mould which contained considerably more organic matter than the loam.[1] Similar results were subsequently obtained with loam taken from a local *sal* forest.[2] In the latter soil the injurious action can be strikingly demonstrated by growing the plants in non-porous glazed pots, the drainage holes at the base of which are subsequently closed by corks when the seedlings are well established. In such cases, while evaporation can take place freely from the surface of the soil, no evaporation is possible from the sides of the pots and the water falling on the soil surface accumulates at the base of the pot, thus forming an artificial water table at the base of the pot. In such cases when the pots are placed in full sunlight

[1] *Indian Forest Records*, vol. 4. part I, pp. 17, 19 (1914).

[2] *L. c.*, p. 30.

PLATE

Fig. 1. Several of the Sal seedlings in pots 14 and 19 have shed their leaves as a result of placing dead Sal leaves on the surface of the soil. In pots 15 and 18 to which no dead leaves were added the seedlings are quite healthy. Photograph taken $3\frac{1}{2}$ months after the dead leaves were added.

Fig. 2. Photograph of the pots shown in Fig. 1 above taken one month later. Nearly all the seedlings in pots 14 and 19 have now shed their leaves.

in the open and supplied only with the local rainfall, the seedlings begin to get unhealthy in about 10 days and, unless the conditions are altered, eventually die.

Plate XXIV shows *sal* seedlings growing under these conditions, pots 7 and 9 being uncorked while 6 and 8 have been corked for 52 days. Previous to corking, the number of healthy plants in 7 and 9 was exactly the same as that in 6 and 8. Note the healthy plants in 7 and 9 as compared with those in 6 and 8.[1] Similar results can, however, be produced by a procedure which to some extent is the reverse of the above, *viz.*, by opening the drainage holes at the base of the pots and then retarding evaporation from the upper soil surface by covering it with a layer of dead leaves.

For the purpose of this experiment seed is sown as before in the glazed pots, the drainage holes at the base of which are left open. When healthy seedlings have been thoroughly established, the surface of the soil in some pots is covered with a layer of dead *sal* leaves while no such covering is placed in the control pots. If the soil is then kept moist in all the pots, either by artificial watering or natural rainfall, the seedlings in the pots with dead leaves soon become unhealthy. Plate XXV, fig. 1 shows examples of such plants : 14 and 19 are pots with dead leaves on the surface of the soil, while 15 and 18 are pots with no dead leaves. When the dead leaves were placed in position there were 39 healthy plants in the former and 37 in the latter. The photograph was taken 3½ months afterwards, and it will be seen that a number of the plants in the former have shed their leaves. Plate XXV, fig. 2 shows the same plants a month later when nearly all the plants in pots 14 and 19 had shed their leaves. It is interesting to note that if the pots are filled with sand instead of forest loam no injurious effect is produced by the dead leaves. Plate XXVI, fig. 1 shows *sal* seedlings growing in sand, pot 23 has dead leaves on the surface, while pot 22 has no dead leaves. This photograph was taken 3½ months after the leaves were placed in position and no injurious effect had been produced. In these experiments the layer of dead

[1] *Indian Forest Records*, vol. 4, part III, p. 90 (1916).

leaves was six leaves thick, which is roughly equivalent to the annual leaf-fall in a well stocked natural forest.

Simultaneously with these pot experiments a series of experiments have been carried out in the Dehra Dun *sal* forests. These have shown that, whereas in the shade of the forest germination and seedling development during the rains is uniformly poor, even when the soil-covering of dead leaves is removed and the soil dug, excellent seedling growth can be obtained if the trees are felled in narrow strips or small patches and the seed then sown in the clearings where the soil is exposed to the sun and air. In the former case the soil invariably contained more water and organic matter than in the latter and the unhealthy seedlings invariably showed more or less extensive rotting of the roots. That the injurious agent is here a soil factor and not deficient light is clearly shown by the fact that if pots containing sand are placed in the shade of the forest, healthy seedlings with well-developed roots can be produced in them without difficulty. Plate XXVII, fig. 2 shows the development of *sal* seedlings in a cleared patch 60 ft. in diameter, and figure 1 of the same Plate shows the corresponding development in the shade of the adjacent forest. In both cases the seedlings are two years old.[1]

In all the experiments noted above, both in the pot cultures and in the forest, the symptoms shown by the unhealthy seedlings are the same. The first sign of disease is seen in the blackening and death of the tender root-tips and rootlets, the damage then spreading, unless the conditions are ameliorated, until the entire root system becomes black and rotten. It is significant that above ground the seedlings may appear quite healthy with green leaves when a number of the deeper roots are dead and rotten. This appears clearly to indicate that the injurious agent is a soil factor and the symptoms convey the impression of a localized poisonous action rather than of a general starvation effect due to lack of essential food materials. Above ground the first sign of trouble is seen in the leaves turning pale and hanging vertically downwards instead of remaining horizontally extended. Plate XXVI, fig. 2 shows healthy seedlings in the two pots on the left and in two pots on the right those showing the

[1] *Indian Forest Records*, vol. 4, part II (1916).

Fig. 1. Photograph of healthy Sal seedlings growing in sand taken $3\frac{1}{2}$ months after a layer of dead Sal leaves had been placed on the surface of the soil in pot 23. No dead leaves were added to pot 22. No injurious effect has been produced by the dead leaves.

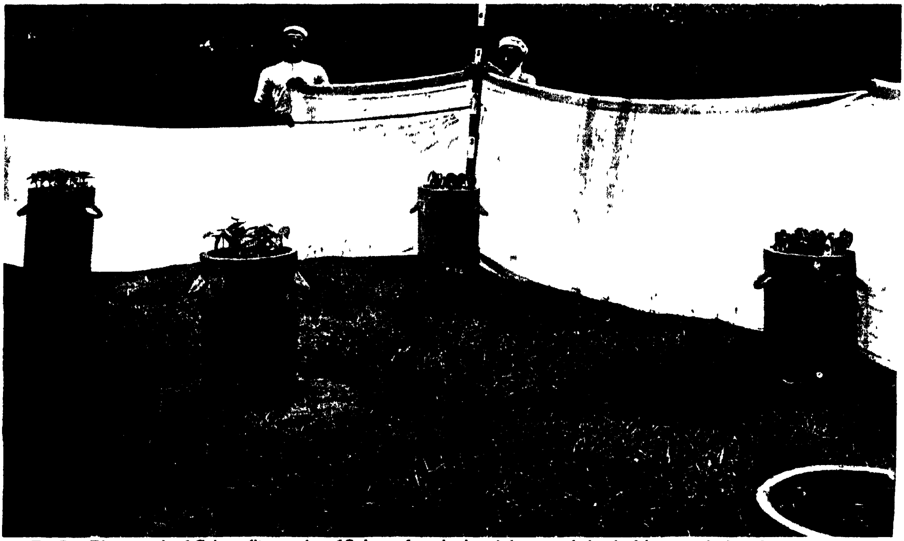


Fig 2. Photograph of Sal seedlings taken 13 days after the basal drainage holes had been corked in the two pots on the right. In these pots the seedlings are showing the first signs of trouble from bad soil-aeration, the leaves hanging vertically downwards. In the two pots on the left which were not corked the seedlings are healthy with leaves horizontally extended.

first signs of trouble from bad soil-aeration 13 days after the pots had been corked. The leaves eventually turn brown and drop off. Organisms such as bacteria and fungi are usually absent from the diseased roots at first but may invade the damaged tissue later. It must be noted that the injurious factor may and indeed usually does cause severe damage in a soil which, although being moist, is still far from being in the condition usually associated with the term "waterlogged." Experiment has shown that 100 per cent. of *sal* seedlings may be killed or seriously damaged by this factor when no water is standing on the surface of the soil and when there is a considerable water-free air-space near the roots. Again, although a moist condition of the soil undoubtedly increases the injurious action, it can be easily shown by water-culture experiments that water in itself cannot be the injurious factor. In Plate XXVIII, fig. 1 are seen *sal* seedlings which have been growing in a water-culture solution for four months and which show a vigorous development of healthy roots especially near the apex. As a general rule no difficulty is experienced in growing healthy seedlings in this way when air is allowed access to the culture solutions.

In 1915 an experiment carried out at Dehra Dun showed that when water was held in contact with the *sal*-forest loam mentioned above in glazed non-porous pots it became heavily charged with CO_2 and impoverished as regards its supply of dissolved oxygen. In 1916 a further experiment showed that when rain water, with an initial content of 1 milligram CO_2 and 7 milligrams oxygen per litre, was held in contact with this soil in glazed non-porous pots which were placed in full sunlight in the open, the CO_2 rose to from 60 to 70 milligrams in two days while the oxygen fell to 1 milligram. After 28 days the CO_2 rose to 230 milligrams. These changes took place in soil in which no plants were growing and were therefore apparently due chiefly to the activity of the living organisms in the soil. The diagram given below indicates the changes in the dissolved gases observed in rain water which was kept in contact with this soil for 19 days in corked glazed pots which were placed in the shade and in which *sal* seedlings were growing. In this case, the water added to the pots had an initial content of

4·8 milligrams oxygen and 5 milligrams CO_2 and the diagram shows that in 19 days the CO_2 had risen to 163 milligrams, this increase being correlated with a fall in the oxygen content which, at the end of the period, was 1·2 milligrams per litre. At the close of this period, in 95 per cent. of the *sal* seedlings growing in these pots the roots were completely dead and rotten.

In rain 5 mg. CO_2

After	4 days in soil		81	mg.
,,	6 ,,	,,	95	,,
,,	9 ,,	,,	100	,,
,,	16 ,,	,,	138	,,
,,	19 ,,	,,	163	,,

In rain 4·8 mg Oxygen

After	6 days in soil		2·6	mg.
,,	9 ,,	,,	1·9	,,
,,	16 ,,	,,	1·8	,,
,,	19 ,,	,,	1·2	,,

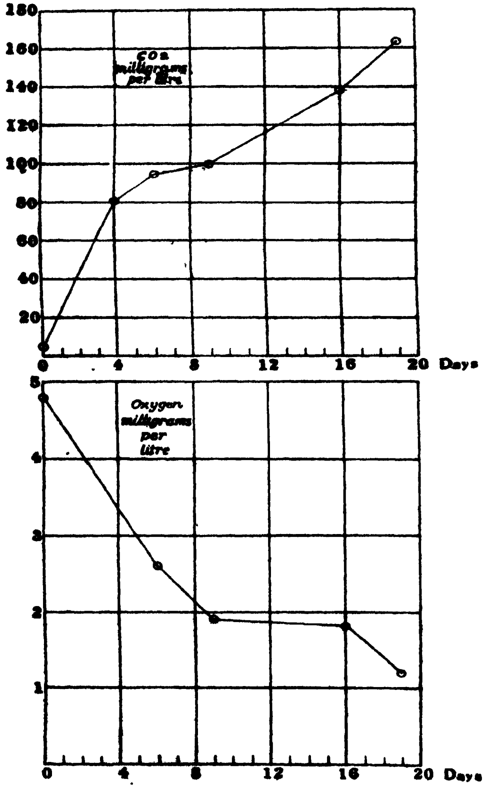


Diagram showing changes in the dissolved gases found in rain water which was held in contact with *sal*-forest loam for 19 days in corked pots.

All the figures quoted above represent the quantities of these gases which were found dissolved in the percolation water drawn off from the base of the pots.

PLATE XXVII.

Fig. 1

Forest shade plot V. Photograph taken 20th July, 1915. Note the appearance of the 2-years-old seedlings surviving in the plot.

Fig. 2.

Forest plot IV. An area 60 ft. in diameter was here clear-felled in May, 1913. The photograph was taken on 20th July, 1915. Note the vigorous 2-years-old seedlings surviving in the plot.

So far as our experiments, therefore, have gone at present they show that the injurious action on the roots of *sal* seedlings is associated with a very small oxygen and high carbon dioxide supply. That a deficiency of oxygen may be injurious to roots is usually accepted by physiologists and is indicated by such water-culture experiments as the one quoted by Mr. Howard. The effect of this factor on the roots of *sal* seedlings still requires to be investigated.

The effect of various quantities of CO_2 gas on these roots, however, has been tested by us, simultaneously with the pot experiments mentioned above, by growing the seedlings in water-cultures and bubbling the gas through the culture solutions.

So far as these water-culture experiments have gone at present they show that, when the concentration of the gas reaches roughly 500 milligrams per litre and above, the delicate root-tips and rootlets of vigorous *sal* seedlings are blackened and killed and the production of new roots is inhibited, the appearance of the damaged roots resembling that of those found in badly-aerated soil. Plate XXVIII, fig. 2 shows the root system of two *sal* seedlings which have been grown in water-culture for 19 days. The one on the right is healthy and was grown in an aerated solution while the one on the left has been gassed for two minutes daily, the concentration finally attained being 600 milligrams CO_2 per litre of water. The fact that the concentration required to produce this injurious effect in water-cultures is considerably higher than that which exists in the percolation water taken from pots in which *sal* seedlings are suffering severely from the injurious factor would appear, at first sight, to put CO_2 out of court as a possible cause. It is believed, however, that this conclusion is not yet justified. During these culture experiments it was noticed that those roots which happened to be near the exit of the gas tube were blackened and killed when those further away still remained uninjured, and also that healthy roots were often produced near the upper surface of the solution which was in contact with the air and farthest removed from the gas tube mouth while the roots deeper down were obviously unhealthy. It is believed that differences in concentration of this kind are even more marked in

the soil than in water-cultures such as those dealt with above. It thus seems possible that extensive damage may be done to the roots when the concentration of CO_2 in the mass of the percolation water filling the pore-space in the soil is too weak to cause injury. It must also be remembered that in badly-aerated soil there are apparently always two injurious actions at work together, *viz.*, a deficiency of oxygen and an excess of CO_2, and it is probable that the injurious action of CO_2 depends largely on the quantity of oxygen available.[1] There is reason to believe that a deficiency of oxygen is in itself injurious to the roots while such a deficiency appears to be invariably correlated with an accumulation of CO_2 and possibly also of other poisonous substances. At present, therefore, it seems probable that the most reliable indication of the conditions of aeration in the soil will be obtained by determining the quantity of oxygen and CO_2 existing in the soil and that we may define a badly-aerated soil as one in which there is a deficiency of oxygen and an excess of CO_2.

To determine whether this is correct or not, further extensive experiments are required in which determinations of these gases should be correlated with careful observations on the root growth. In forestry it is important that we should be able to determine quickly when the conditions of soil-aeration are becoming unsuitable for the healthy development of our trees so that the treatment may be altered without undue loss of time and before serious damage has been done. Analysis of the soil gases at present promises to be the best means of effecting this, and it is with the hope that the attention of some of those eminent chemists who are present here to-day may be attracted to the subject and that they will help us to elaborate easy and practical methods of soil-gas analysis suitable for application in the forests that the present paper has been written.

[1] Thus Kidd has shown that, with 5 per cent. oxygen, 9-12 per cent. carbon dioxide inhibits the germination of seeds, whereas, with 20 per cent. oxygen, 20-25 per cent. carbon dioxide was required to produce inhibition with a temperature of 17° C. (*Ann. Bot.*, XXXI, p. 457, 1917.)

PLATE XXVIII.

Fig. 1. Sal seedlings which have been growing in a water-culture solution for 4 months and which show a vigorous development of healthy roots, especially near the apex.

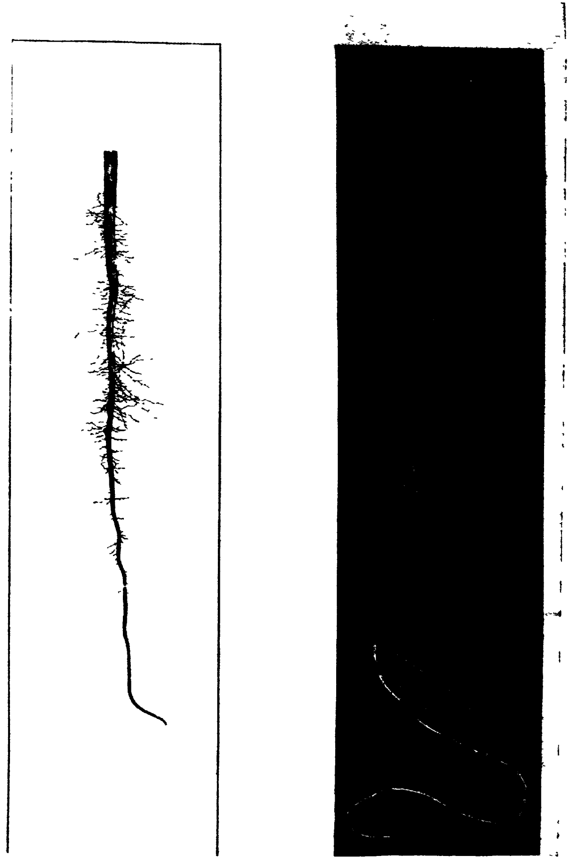


Fig. 2. Showing the root-systems of two Sal seedlings which have been grown in water-culture for 19 days. The one on the right is healthy, showing numerous healthy young roots, and was grown in an aerated solution, while the one on the left has been gassed for 2 minutes daily, the concentration finally attained being 600 mg. CO_2. per litre of water. In this case the root is dead at the apex and there are no healthy young roots.

From what has been said above it will be seen that soil-aeration apparently depends chiefly on :

(1) The amount of water in the soil.
(2) The amount of organic matter in the soil.
(3) The number and kind of soil organisms.
(4) The rate at which currents of air, or water with oxygen in solution, penetrate into and percolate through the soil.

In the *sal*-forest loam used in the pot experiments mentioned above, bad aeration appears to depend chiefly on the first three of these factors, but experiments have shown that soil texture and rate of percolation are no less important. Plate XXIX, figs. 1 and 2 show the growth of *sal* seedlings of the same age in porous and dense loam respectively. In the latter the time required for ½″ of water to penetrate below the surface was 750 seconds whereas in the former it was 46 seconds. Note the respective root growth of the seedlings in the two cases. In dense soil germination is reduced, more seedlings die during the rains of bad aeration and of drought during the dry season owing to poor root development.

It is important to note that the various agencies which influence soil-aeration can be controlled to a considerable extent by ordinary forest operations apart from the obvious but expensive methods of draining and soil cultivation. Thus the quantity of water, of soil organisms, and of organic matter can be regulated by varying the shade and quantity of dead leaves added to the soil and also by the controlled use of fire. Texture is also influenced by the amount of organic matter in the soil and also by such factors as the grazing of cattle, both of which are capable of regulation. In some cases the temporary encouragement of the growth of certain grasses and other herbs, the roots of which are much sought after by such forest cultivators as rats and pigs, is an important factor in improving soil texture. The felling of trees and the subsequent decay of the subterranean roots is also an important factor in influencing soil-aeration, a point which has recently been emphasized by Mr. Howard. There is thus good reason to believe that,

provided we can elaborate a method, by soil-gas analysis or otherwise, of quickly and accurately identifying a condition of bad soil-aeration, we shall, at any rate in many cases, be able to apply the necessary remedy.

As regards the general importance of soil-aeration in Indian forestry, it must I think be accepted that this factor is of primary importance in the case of the *sal*, the only species which up to date has been studied in any detail in this connection and regarding which our knowledge is still very imperfect. In the moist forests of Dehra Dun it has been shown that the establishment of seedling growth depends primarily on this factor, and Mr. R. S. Troup has recently shown that this is also the case in the moist *sal* forests of Bengal and Assam.[1] In the latter case it is interesting to note that subjecting the forest to fires is now said to be improving the seedling growth. Apart from the question of the establishment of seedlings, Mr. R. G. Marriott has recently ascribed the poor development of older trees to this factor and suggests that, owing to it, the trees may practically cease to grow during the rains which ought to be the period of most vigorous growth.[2]

Finally, it is interesting to note that, although the *sal* root fungus *Polyporus Shoreæ* is widely distributed throughout the *sal* forests of India, so far as is known at present, it only causes serious damage in those wet forests of Bengal and Assam in which the conditions of soil-aeration are known to be particularly unfavourable. Bad soil-aeration by producing a diseased and sickly condition in the roots may be a factor of great importance in facilitating the attacks of injurious root-fungi of this class. It is interesting to note from an ecological point of view that the natural distribution of the *sal* appears to be regulated largely by this factor. Thus good *sal* forests are not known to occur on really wet soils unless these soils consist chiefly of gravel and sand. On loam the best *sal* forests are limited, so far as we know at present, to those areas which are well drained and where the soil texture is good.

[1] *Note on the Forests of the Duars*, Simla, 1915, p. 36.

[2] *Indian Forester*, vol. XLIII, p. 444.

PLATE XXIX.

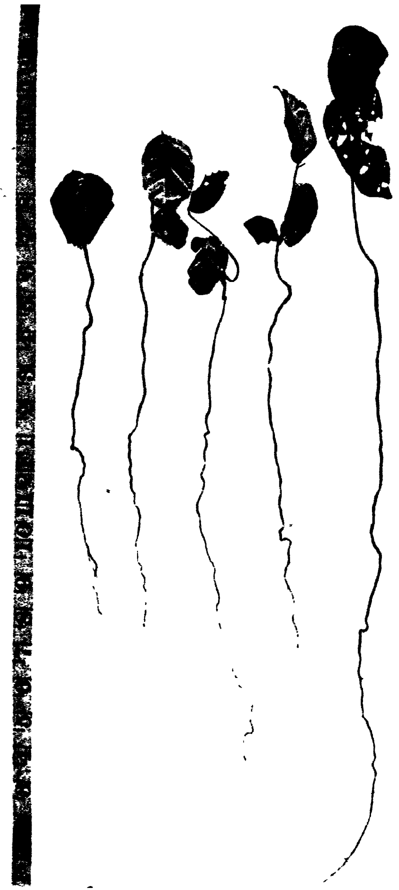


Fig. 1.

Fig. 2.

Showing the root-development of Sal seedlings at the end of the first rains; in Fig. 1, plants which have been grown in porous well-aerated loam and, in Fig. 2, plants which have been grown in dense badly aerated loam. Note the respective root-growth in the two cases.

These facts of distribution accord precisely with the results of the Dehra Dun pot experiments which have shown that whereas on well-aerated sand it is practically impossible to give too much water to *sal* seedlings, the latter are very susceptible to injury by bad soil-aeration in loam.[1]

There is good reason for believing that several other species of our most valuable Indian trees are no less susceptible than *sal* to the influence of soil-aeration, and, speaking generally, there can be little doubt that this factor is of great importance in Indian forestry whether considered with reference to its effect on the healthy growth and development of seedlings and trees or its possible connection with injurious diseases or, finally, with regard to its ecological importance in influencing the distribution of species and types of vegetation.

Before leaving this subject I venture to suggest that the following, which of recent years have attracted much attention, may possibly be found to be primarily cases of bad soil-aeration. Pickering's experiments at Woburn have demonstrated the injurious effect of grass on fruit trees, which has been attributed to the presence in the soil of a toxin which is either produced directly by the grass roots or from the organic remains of such plants. A dense growth of grass is correlated with an accumulation of dead roots, leaves, and other debris in the surface soil, which would ordinarily encourage the rapid reproduction of the soil organisms engaged in the decomposition of organic matter. We should naturally expect that rain water, percolating through such a layer of grass, would tend to be deprived of its oxygen by the numerous living grass roots and soil organisms and would become heavily charged with CO_2. Pickering notes that when such "toxic" water is exposed to the air for 24 hours its toxic property is found to have entirely disappeared.[2] Exposure to the air would tend to make good a

[1] That soil-aeration influences the distribution of types of vegetation other than *sal* forest is indicated in *Indian Forest Memoirs*, Bot., vol. I, 1, p, 46 (1911) and in *Indian Forester*, XLII, p. 344 (1916.)

[2] *Annals of Botany*, 31, p. 184, (1917).

deficiency of oxygen and to dissipate an accumulation of CO_2 by diffusion.[1]

The work of Russell and others at Rothamsted has shown that in soils which are kept moist, warm, and richly supplied with organic matter plant growth is frequently unsatisfactory and this is correlated with an exceptional development of the larger soil organisms such as protozoa. May not this unusual development of large organisms be responsible for a deficiency of oxygen and an accumulation of carbon dioxide, and thus for a condition of bad soil-aeration?

In conclusion, although I have enjoyed the privilege of putting these points before the members of the Science Congress, it must not be thought that I, personally, can claim the credit for such results as have already been obtained. For the recognition of the importance of soil-aeration in practical forestry we are indebted to the careful observations of forest officers like Messrs. R. S. Troup and R. G. Marriott, while as regards the experimental work carried out at Dehra Dun the lion's share, including all the chemical work, has been done by Mr. Puran Singh, our Chemical Adviser, and his assistant, Mr. T. P. Ghose, who have carried this through under great difficulties and under constant heavy pressure from other duties.

[1] Mr. Howard made a similar suggestion in 1915, *see* "Soil Ventilation," *Pusa Agr. Res. Inst. Bulletin No. 52*, pp. 22, 23.

PRESENT POSITION AND FUTURE PROSPECTS OF THE NATURAL INDIGO INDUSTRY.

BY

W. A. DAVIS, B. Sc., A. C. G. I.,

Indigo Research Chemist to the Government of India.

III. THE FUTURE OF NATURAL INDIGO IN INDIA.

HAVING in the preceding article (*Agricultural Journal of India*, vol. XIII, page 206) described the existing methods of indigo culture and manufacture, I will now consider the possibility of effecting improvements in these. It is clear that very great improvements *can* be made and after two years' study of the question I have formed the opinion that the future of natural indigo is by no means a hopeless one provided steps are taken to realize such improvements as are clearly possible. The fate of natural indigo will be determined by several factors, each of which has its own special importance :—

(*a*) Improvements in agriculture.
(*b*) Improvements in actual manufacture, either by chemical or bacterial means.
(*c*) Improvements by botanical selection.
(*d*) Improvements in methods of marketing the product.
(*e*) Improvements in business organization.

I will now deal with these different questions in turn.

(*a*) IMPROVEMENTS IN AGRICULTURE.

The agricultural side of the problem is to my mind the most serious one in Bihar at the moment and the one needing most immediate attention. On the other hand, it is on this side that,

from the evidence now available, most immediate improvement seems possible. Such improvement must however necessarily be gradual and a matter of time. Whether natural indigo can hold its own in the future against the competition of synthetic, is mainly a question of cost of production. If the cost of each pound of natural indigo can be lowered so as to enable it to compete with synthetic in price, providing the natural indigo be put on the market in the same convenient and standardized form as the synthetic, there is every reason to believe that it will be able to hold its own against the synthetic dye. The dominant factor is undoubtedly the price per unit of indigotin.

The *possibilities* of natural indigo are best made clear by the following considerations. High-quality Java indigo leaf contains 0·7 to 0·8 per cent. of indigotin[1] at the time when it is ripe for cutting. Now a yield of 100 to 120 maunds of green plant per acre can be obtained *on lands in good condition*, and the plant will contain about 50 per cent. by weight of leaf. The following table gives the theoretical yields in seers of 60 per cent. indigo per 100 maunds of plant for different percentages of leaf or plant and for different percentages of indigotin in the leaf :—

TABLE I.

Theoretical yields of 60 *per cent. indigo per* 100 *maunds of plant.*

Per cent. of leaf on plant	YIELD IN SEERS OF 60% INDIGO WHEN THE LEAF CONTAINS			
	1·0%	0·8%	0·6%	0·5% indigotin
40	26·70	21 4	16·0	13·35
50	33·33	26·7	20·0	16·66
60	40·00	32·0	24·0	20·00

The numbers of this table also give the yield in seers of 60 per cent. indigo *per acre* if each acre be assumed to yield 100 maunds of plant; if the yield of plant per acre be as high as 120 maunds

[1] Rawson's analyses of Java indigo leaf (see *Report to Bihar Planters' Association*, 2nd Edn. 1907) in several instances showed 0·9 and even 1 per cent. of indigotin. Nearly 1,000

(and in some of the better soils of Bihar at the present time the yield is actually greater than this) the following table gives the result :—

TABLE II.

Theoretical yield of 60 per cent. indigo on the assumption that each acre yields 120 maunds of green plant.

Per cent. of leaf on plant	YIELD IN SEERS OF 60% INDIGO WHEN THE LEAF CONTAINS			
	1·0%	0·8%	0·6%	0·5% indigotin
40	32·0	25·7	19·2	16·0
50	40·0	32·0	24·0	20·0
60	48·0	38·4	28·8	24 0

These figures are useful in forming an idea of the possibility of natural indigo competing in price with synthetic in the future. Provided that the agriculture be improved so that the yield of green plant be brought up to the level of, say, 120 maunds per acre and the methods of manufacture improved so that the whole of the dye stuff of the plant be extracted, we will now show that the natural dye should be able to compete very favourably with the synthetic article.

The German price for synthetic before the war in the United Kingdom was 8*d*. per lb. for 20 per cent. paste,[1] which would be

analyses made by Parnell (*Report of Sirsiah Station*, 1913) showed extraordinary variations in individual plants, the following table summarizing the results :—

Year	No. of analyses	Average	Highest	Lowest
1910	200	0·54	0·76	0·35
1911	353	0·61	0·92	0·37
1912	336	0·50	0·78	0·32

The content of indigotin apparently increases in the leaf up to a maximum which is reached somewhere about the time of cutting. There is no doubt too that the ordinary Java plant now grown in Bihar is a mixture of a large number of different varieties (many differences are obvious merely to the eye) and Parnell's work shows that these varieties differ widely in indigotin content.

It should be noted that both Parnell and Rawson analysed their plant by the persulphate method. From a large number of comparative analyses made by the writer last season this method apparently gives results which are at least 20 per cent. lower than the more correct values obtained by the isatin method. It is therefore a conservative estimate to assume that *good* quality Java plant contains 0·7 to 0·8 per cent. of indigotin.

[1] See *Proceedings of the Conference on Natural Indigo held at India Office*, September 20, 1915.

equivalent to 60 per cent. natural indigo at 2*s*. per lb. or Rs. 112 per maund of 74·66 lb. As regards the actual cost of production of natural indigo, planters' opinions differ, but Mr. D. J. Reid, one of the most successful planters, stated at the Delhi Conference[1] that with a yield of 35 seers to the acre, natural indigo could be produced at Rs. 40 a maund. Mr. G. R. MacDonald hesitated to accept this figure and "taking bad years into account, doubted whether the average cost of production would be less than Rs. 80 a maund." It should be pointed out here that Mr. Reid's estimate is based on the assumption of a *steady* output of 35 seers, whereas Mr. Macdonald's takes into account *bad years* in which the crop would give considerable lower returns. Mr. Bernard Coventry, C.I.E., late Agricultural Adviser to the Government of India, has recently expressed the view that if at his factory (Dalsing Sarai) "we could only grow the plant properly, it would give us at least 20 seers a bigha and with such a yield I would undertake to undersell synthetic indigo at practically any price." Mr. Reid, it should be pointed out, has since 1905 been one of the largest growers of the Java plant—in the year 1911 and 1912 for example, he had nearly 2,500 bighas under Java indigo[2].

Table II given above shows that with Java indigo plant containing 0·8 per cent. of indigotin in the leaf and yielding 120 maunds of plant, 50 per cent. of which is leaf, to the acre, the theoretical yield of 60 per cent. indigo is 32 seers. If the quality of the leaf were increased by careful selection (and the writer regards this is quite possible in view of Parnell's early experiments at Sirsiah, carried out under most disadvantageous conditions) so that the average amount of indigotin in the leaf were 1 per cent., so high a theoretical yield as 40 seers of 60 per cent. indigo would be possible. If by suitable selection the proportion of leaf to stick in the plant were at the same time increased, so that it contained 60 per cent. of leaf containing 1 per cent. of indigotin, the theoretical yield would reach the enormously high value of 48 seers to the acre.

[1] *Proceedings of the Conference on Indigo held at Delhi*, February 22, 1915.

[2] See his article "Ten years' practical experience of Java Indigo in Bihar," *Agricultural Journal of India*, vol. XII, part I, January 1917.

The deterioration of Bihar indigo soils and the necessity of proper manuring.

In the writer's opinion the most important immediate factor in the indigo problem is that the deterioration of Bihar soils, which has followed neglect of proper manuring in the past, should be remedied. On the promptitude of the adoption of remedial measures will largely depend the possibility of natural indigo being produced in Bihar at a sufficiently low price to compete with the synthetic article in the immediate future.

In a special pamphlet[1] recently circulated to Bihar Planters, the writer has dealt at considerable length with the evidence which shows that during the past 20 years the indigo soils of Bihar have been rapidly stripped of fertility owing to the using up of the small reserves of available phosphate. It has been pointed out that unless proper manuring with superphosphate is *immediately* adopted, there is every indication that during the next few years the yield of indigo per acre will fall off throughout Bihar in an alarming manner and that it will then become absolutely impossible for natural indigo to compete with the synthetic dye—the final extinction of natural indigo will then be certain.

The indications of deterioration of the soils of recent years are numerous. Not only is such deterioration clear from actual analysis of the soils but wherever proper trials with superphosphate as a manure have already been made, the response has been remarkable, showing that the deficiency in phosphate has been the principal trouble.

When the Java plant was first introduced into Bihar and the early difficulties in the way of its cultivation had been overcome, the returns from this plant were so remarkable that it was confidently expected that its general adoption would save the indigo industry. In many cases the produce of indigo per bigha was from three to four times that given by the old Sumatrana plant—two and even three heavy cuttings of leaf were obtainable. The

[1] Indigo Publication, No. 1, *A Study of the Indigo Soils of Bihar*, pp. 75 (1918), by W. A. Davis.

data given by Mr. D. J. Reid in his article "Ten years' practical experience of Java indigo in Bihar" are very instructive. In the year 1906 to 1907 we have the following comparisons :—

TABLE III.

Belsand Head Factory, Season 1906-1907.

Java Indigo							Sumatrana Indigo						
Cuttings	Bighas	Indigo			Produce per bigha		Cuttings	Bighas	Indigo		Produce per bigha		
		Mds.	Srs.	Ch.	Srs.	Chtks.			Mds.	Srs.	Srs.	Chtks.	
1st	666	172	31	8	10	6	1st	712	73	10	4	2	
2nd	645	160	23	12	9	15	2nd	171	4	10	1	0	
3rd	303	21	14	4	2	13	......	......	.....		.....		
	Total ...	354	29	8	23	2		Total ..	77	20	5	2	

Bhagwanpur Factory, Season 1906-1907.

Java Indigo						Sumatrana Indigo				
Cuttings	Bighas	Indigo		Cake produce per bigha		Cuttings	Bighas	Indigo	Cake produce per bigha	
		Mds.	Srs.	Srs.	Chtks.			Mds.	Srs.	Chtks.
1st	133	42	18	12	12	1st	670	99	6	0
2nd	117½	44	16	15	2	2nd	230	24	4	2½
3rd	53	11	14	8	9	......	......	......	......	
	Total ...	98	8	36	7		Total ...	123	10	2½

At Belsand Factory the yield of indigo per bigha (which is the principal thing for the planter) was more than four times as great with Java indigo as with Sumatrana; at Bhagwanpur it was slightly less than four times. The yield of cake produce per bigha reached the remarkably high figure at Bhagwanpur of 36 seers 7 chattaks (*i.e.*, 41½ seers per acre) whilst at Belsand it was 23 seers 2 chattaks (*i.e.*, 27 seers per acre). In fact, the value obtained at Bhagwanpur actually exceeded the value of 32 seers per acre corresponding (according to Table II) with the theoretical yield of 60 per cent. indigo from 120 maunds of green plant to the acre, with a leaf percentage of 50 and an indigotin content of 0·8 per cent.; it even

exceeded that possible with plant containing 60 per cent. of leaf with the other factors the same. At Belsand (where it will be shown the soil is inferior to that of Bhagwanpur) the yield per bigha was somewhat lower, but still so high as 23 seers.

The significance of the above results lies in their clearly demonstrating the *possibility* in actual estate practice of obtaining very high yields of indigo per acre from the Java plant, when the soil conditions are favourable. With such yields as 35 seers to the acre, Mr. Reid (*see* page 444) has calculated that natural indigo could be produced at Rs. 40 per maund, which is far below the actual pre-war selling price of synthetic indigo (Rs. 112). With such a yield it should be an easy matter for natural indigo to compete with and hold its own against the synthetic product. Even with the considerably lower yields obtained at Belsand (23 seers per bigha) there should be no difficulty.

Unfortunately the promise which the Java plant first held out was not long maintained. For two or three years phenomenal results were obtained at many factories; the plant grew magnificently, required little trouble in cultivation, and in several cases the plant was carried on from season to season without re-sowing. But in the year 1907 trouble began to be experienced: two diseases appeared simultaneously in Bihar, the one due to an insect pest "Psylla," and the other the far more destructive "wilt" disease. Owing to the latter disease, which led to the partial or complete dying out of *khoonties* or the failure of seed plant, it gradually became impossible to obtain sufficient seed for general use and the output of indigo rapidly fell off. In 1911 the General Secretary of the Bihar Planters' Association wrote to the Inspector-General of Agriculture: "The disease this season totally destroyed the *khoontie* crop of Bihar and had there been no disease at least 10,000 maunds more indigo could have been made, valued at Rs. 15,00,000 or £100,000 sterling. The condition of affairs is most serious and, what is of the greatest importance, the plant that has been kept for seed gives practically no return."

Since 1911 the *khoontie* plant throughout Bihar has died out partially or completely each year. Many estates now invariably

fail to give *khoonties* at all and on the majority it is impossible to obtain seed from the Java plant. At first it was thought that the "wilt" might be a fungal or bacterial disease but Dr. E. J. Butler at Pusa could find no evidence in support of the former view nor Mr. C. M. Hutchinson of the latter. **The writer considers that the disease is entirely due to phosphate starvation** owing to soil deterioration caused by continual cropping and has recently published a large number of analyses and facts in support of this view[1]. It is not necessary here to go into the evidence in detail, but I will briefly deal with the question from a general point of view.

In the first place, there is strong evidence to show that during the past 20 years the soils have undergone considerable deterioration as regards the amount of available phosphate present. In practically all cases where analyses have been recently made, the soils have been found to be singularly deficient in "available phosphate." In most cases the amount is far below the 0·01 per cent. generally regarded as necessary for fertility. A large number of Bihar indigo soils contain less than 0·0002 per cent., whilst in several only the merest traces can be detected.

Actual factory data indicate in several cases that the deterioration of yield from the Java plant has been progressive, and has taken place over a series of years. For example, if we examine Table IV which shows the yields from 1905-1912 at Belsand and Bhagwanpur factories, the gradual and continuous falling off of yields is—making allowances for slight seasonal variations—quite apparent.

The first symptom of deterioration in the soil at Belsand was the gradual failure of seed yield, generally the first indication of phosphate starvation. When the Java plant was first grown at Belsand it gave very high yields of seed—15 maunds to the acre in 1904-1905. Next year the yield of seed fell to 9 maunds and in 1906-1907 the yield is described (*see* D. J. Reid's article) as "disappointing." Up to this time, 1906-1907, the green plant had given astonishing yields—even after the seed began to fall off the cuttings of leaf plant were very good. In the seasons 1906-1907 and 1907-1908 three cuttings of leaf were taken, the total yield per bigha

[1] *Indigo Publication*, No. 1.

Statement showing the yield of cake indigo in different years.

Year	BELSAND							BHAGWANPUR						
	1st cut per bigha, seers	2nd cut per bigha, seers	3rd cut, seers	Total average per bigha, seers	Area cut, bighas	Total make, mds.	REMARKS	1st cut per bigha, seers	2nd cut per bigha, seers	3rd cut, seers	Total average per bigha, seers	Area cut, bighas	Total make, mds.	REMARKS
1905–1906	9–7¼	......	...	......	289	68	Plant over-matured when put in vats.	......	... ..	..	.. ...	......	...	......
1906–1907	10–6	9–15	2–13	23–2	1st cut 666 2nd ,, 645 3rd ,, 303	355	No wilt.	12–12	15–2	8–9	36–7	1st cut 133 2nd ,, 117½ 3rd ,, 53	98	No wilt.
1907–1908	8–10	9–9½	5–4	23–7½	1st ,, 1,334 2nd ,, 1,191 3rd ,, 233	605	No wilt.	12–2	9–11	.	21–13	1st ,, 908 2nd ,, 614	423½	All 2nd cuttings could not be utilized owing to dam impeding water for manufacture. No wilt.
1908–1909	5–0	1–0	.	6–0	1st ,, 1,559 2nd ,, 269	203	Wilt appeared in *khoonties*, plant largely damaged by hail in May.	6–0	2–2½	. .	8–2½	1st ,, 945 2nd ,, ...	146	No wilt. Plant damaged by hail-storm in May.
1909–1910	7–1	6–7	.	13–8	1st ,, 1,606 2nd ,, 507	366	*Khoonties* largely lost by flood.	8–7½	5–2	.	13–9½	1st ,, 1,137 2nd ,, 242	272¼	No wilt.
1910–1911	7–3	2–15	..	10–2	1st ,, 1,533 2nd ,, 385	299	*Khoonties* badly attacked by wilt.	8–4½	8–12¼	...	17–1	1st ,, 1,132 2nd ,, 877	428	No wilt.
1911–1912	4–14	2–1	...	6–15	1st ,, 1,470 2nd ,, 778	220	Worst season* recorded for wilt of *khoonties*.†	6–3	3–3	...	9–6	1st ,, 925 2nd ,, 746	203	No wilt this year.

Seed yield "*Belsand*" ... 1904—05 15 mds. per acre (uncut plant).
1905—06 .. 9 ,, ,, ,, ,, ,,
1906—07 .. "Yield disappointing" ,,
1907—08 ... No uncut plant retained : seed from once cut plant, fair.
1908—09 ... First year in which wilt affected yield of green plant.

* After this year owing to bad returns, cultivation of indigo greatly reduced.

† Return per bigha from the *first* cutting was also very poor. Not only was this so but "the yield of indigo per 100 mds. of plant was considerably lower this season than in others," showing an actual deterioration in quality.

at Belsand in the former season being 23 seers 2 chattaks of cake indigo per bigha and 36 seers 7 chattaks per bigha at Bhagwanpur. After 1908 the yield of green plant and leaf rapidly began to fall off (the year 1908-1909 should be omitted from consideration, because in this year a heavy hail-storm in May seriously damaged the whole crop and the abnormally low results are due to this cause). The main falling off at Belsand was due to the development of wilt in the *khoonties*: the following are the values (omitting the year 1908-1909):—

	Khoonties Seers	Chattaks
1907-1908	14	13¼ (includes 3rd cut).
1908-1909	......	
1909-1910	6	7
1910-1911	2	15
1911-1912	2	1

But even the *first* cuttings were affected and showed a considerable and increasing failure, especially after 1910-1911.

Season	First cutting indigo per bigha Seers	Chattaks
1906-1907	10	6
1907-1908	8	10
1909-1910	7	1
1910-1911	7	3
1911-1912	4	14

The *quality* of the first cuttings also deteriorated in a marked way, the yield of indigo per 100 maunds of green plant diminishing considerably (*see* note to Table IV).

At Bhagwanpur a similar falling off of the yield is seen, although up to 1911-1912 *no actual wilt appeared at this factory*: here again the deterioration is most marked in the *khoonties* :—

	Yield of indigo per bigha—*khoonties* Seers	Chattaks
1906-1907	23	11
1907-1908	9	11
1909-1910	5	2 (*khoonties* partly lost by flood).
1910-1911	8	12¼
1911-1912	3	8

The Bhagwanpur soil was in 1906-1907 considerably better than the Belsand soil—hence the surprising yield at this factory of 36 seers 7 chattaks of cake indigo per bigha. The superiority of the soil also appears in the fact that no actual wilt developed at

Bhagwanpur up to 1911-1912, whilst on the adjacent Belsand estate wilt appeared in the *khoonties* in 1908-1909. But that the soil was rapidly deteriorating is clear from the falling off of produce especially from *khoonties*.

The position at the present time.

During the past few years the failure of *khoonties* (second cuttings) has become more and more general each year throughout Bihar—in 1917, *khoonties* failed on many estates where formerly moderate crops were obtained. The actual falling off of the crops in the past two years is seen from the following figures taken from the Indigo Memorandum of the Department of Statistics :—

Year		Area in acres	Yield of indigo
1916-1917	... .	76,500	10,800
1917-1918	... .	85,900	10,300

Thus although the area under indigo was increased in 1917-1918 by 12 per cent. the total produce fell off by nearly 5 per cent., that is, an actual loss in the past year of 17 per cent. If we consider the falling off at individual factories due to the failure of plant the position becomes even more alarming : thus at Belsand—

In 1907-1908, Total produce of cake indigo—604 mds. 27 srs. from 1,334 bighas cultivation.
In 1911-1912, Total produce of cake indigo—220 mds. 7 srs. from 1,470 bighas cultivation.

In both years the *climatic* conditions were very favourable and there was little loss from flooding : *yet the produce fell off in this interval by two-thirds.*

At the present time from returns which have been sent me it appears that the average produce of cake indigo in Bihar is for Sumatrana plant 6 to 7 seers per acre and for Java plant 10 to 12 seers per acre. The yield of *green* plant per acre (as well as the yield of indigo per 100 maunds of plant) is exceedingly variable ranging

for *Sumatrana* plant from 31 mds. (minimum) to 119 mds. (maximum) ;
" *Java* plant " 63 " " " 105 " "

In some cases the yield of green plant per acre from Java indigo has been even less than from Sumatrana owing to the greater loss of *khoonties* by dying out (wilt).

Even with Java plant the yield of indigo is often now only 6 to 7 seers a bigha. Thus at Belsand Table IV shows that land which in 1906-1907 yielded 23 seers of indigo, in 1911-1912 only gave 6 seers per bigha; at Bhagwanpur where in 1906-1907 the yield was 36 seers to the bigha the yield had fallen to 9 seers in 1911-1912.

Is it possible to bring about a return to the former high yields of indigo?

There is no doubt that when the *soil conditions* are satisfactory extraordinary yields of indigo per acre *can* be obtained. This is clear from the Bhagwanpur and Belsand figures; **the Bhagwanpur soil gave, when the Java plant was first grown, the extraordinary return of 41½ seers of Indigo per acre.** The vital question is whether it is possible so to improve the Bihar soils in general by simple methods as to increase the yield of indigo to a value of 20 to 30 seers per acre, a yield which would enable natural indigo easily to compete with the synthetic and pay handsome profits.

In my opinion, from the evidence already available, such improvement is clearly possible—the way lies in continuous and systematic manuring with a readily available phosphatic manure—superphosphate. During the past 100 years the indigo soils have been systematically depleted by the continual growth of indigo, until they have been brought to a condition of absolute starvation.

That the main factor has not been a degeneration of the indigo plant—although *some* deterioration may have occurred—is clear from the fact that when ordinary Bihar seed is now grown *in good soils outside Bihar* the same surprising returns are obtained as were given when the Java plant was first introduced into Bihar. Thus for example at Kot-Chandpur (Bengal) on a soil containing 0·374 per cent. of available phosphate (that is nearly 750 times the amount present in many Bihar soils to-day—those with 0·0005 per cent.) the yield of Java indigo seed obtained last year was 20 maunds per acre. At Jorhat, Assam, with a rainfall of 90″—far higher than in Bihar, so that the fields are frequently waterlogged—the plant grows most luxuriantly. Whereas the indigo plant in Bihar is now on most estates a poor stunted shrub seldom more than

3 to 4 feet high, at Jorhat (available phosphate 0·074 per cent.) it grows most luxuriantly. Mr. Tunstall recently informed me that the Java plants attain a height of 12 to 15 feet, the stem is 1″ to 1½″ in diameter, and the plants yield seed heavily and continuously for several months. At Jalpaiguri (Bengal), with an *annual rainfall of* 150 *inches*, luxuriant plant 12 feet high was obtained—again on a soil very rich in available phosphate (0·0978 per cent.). Climatic conditions, in fact, as shown by Mr. Reid in his article, "have little if anything to do with wilt."

It is in fact a question of some importance—whether it would not be a profitable speculation to take up the manufacture of indigo grown on rich soils outside Bihar, such as those of Jorhat and Jalpaiguri. From such soils, the yields of indigo should be of the order obtained in Bihar when the Java plant was first introduced—25 to 35 seers per acre—a yield which would give handsome profits even at pre-war prices.

That the Bihar soils are capable of very great improvement by proper manuring with phosphates[1] is clear in the few cases where experiments have been systematically made. I have given details of these in my Indigo Publication No. 1 and a former paper in this Journal.[2] I have also, in the Indigo Publication referred to, shown that although the present price of superphosphate is high the increased returns even in the first year will generally more than cover the cost of the manuring. The late Mr. Francis Coventry in February of last year reported to me the results of experiments he had carried out with superphosphate as follows :—

"*The application of* 3 *to* 4 *cwt. of* 22 *per cent. superphosphate per acre on good quality lands but that have not been manured for over two years has given quite three times the yield of mustard on the untreated areas : the results with indigo seed will be much in the same proportion.* When applied to poorer lands the difference in both mustard and indigo seed is even more marked than in the better

[1] That the failure of indigo is not due simply to indigo following indigo in the same lands is clear from the fact that on many estates now indigo fails badly in lands which have been leased out to *raiyats* and have not grown indigo for 3 or 5 years.

[2] "The Phosphate Depletion of the Soils of Bihar," *Agricultural Journal of India*, Special Indian Science Congress Number, 1917, p. 77.

quality lands, **in some cases the yield being half a maund or no crop at all in untreated land as against 4 maunds with phosphate.**" As regards the yield of *green plant* Mr. Coventry stated—"the increase is very great, sometimes half as much again in the first cutting and double the quantity in the second cutting." Where no phosphate was applied the mustard plant frequently died out entirely and the indigo failed to give a second cutting : where superphosphate was used, an excellent mustard crop was obtained.

It should carefully be noted that the maximum effect of super on indigo does not show in the first year, as it takes time to wash down into the subsoil where the indigo feeds—it is the subsoil which is now most deficient in phosphate. Mr. Bernard Coventry writes to me in connection with past trials with superphosphate at Dalsing Sarai—"**The residual results were very remarkable and the considerable profits which Dalsing Sarai made in the years following the application were attributed to it by my brother. Though the expenditure was considerable yet both the immediate and residual effects fully justified it.**" In this case half the total cultivation was treated with superphosphate—about 3,000 acres in all—so that the results are those of actual large scale working.

The manurial experiments made at Pusa[1] have shown that the yield of cereals (maize or oats) is *doubled* by treatment with super alone (as compared with no manure) whilst when super is used in conjunction with green manure (the best form of manuring for cereals) the crop has been increased three- to four-fold. Mr. M. M. Mackenzie has stated that by manuring with superphosphate plus green-manuring at Sapaya the *average out-turn* of oats per acre has been doubled in three years.

	Mds. of 80 lb.
1st year average out-turn per acre	12·00
2nd year " " " "	19·50
3rd year " " " "	23·00

I think it highly probable that by systematic manuring for a period of 5 to 10 years with superphosphate it should be possible gradually to bring back the yield of the Java indigo plant to a high level and that estates on which the yield of indigo has dropped

[1] For data, *see* my article "The Phosphate Depletion of the Soils of Bihar."

to 5 to 6 seers per acre would be able in time to yield 20 to 25 seers, yields which are clearly possible in Bihar, in the light of the Belsand experience (*see* Table IV).

The question of such manuring is one of great importance not only in regard to indigo but also to other crops grown on planters' *zerats*. A good crop of indigo greatly improves the land for subsequent cereal crops, not only by its yielding a good supply of *seet* as a manure, but by its direct action in increasing the supply of nitrogen in the soil—the principal food required by the cereal crop. The great value of the *seet* is well known to planters—in many cases land manured with *seet* is subsequently let to *raiyats* for growing other crops such as tobacco, and the increased rent willingly paid by the *raiyat* for such seeted lands is often surprising.

The present day planter is not merely an indigo manufacturer as in the old times, but a general farmer, and a large part of his income is derived from other crops following indigo and from manured land let to *raiyats* for special crops (tobacco, chillies, etc.). In fact several planters have told me that the other crops grown (with the aid of *seet*) nearly or entirely pay all the costs of the estate. Whatever indigo is made is clear profit—the actual costs of manufacturing indigo are small. Now by proper manuring with superphosphate not only can the yield of *indigo itself* be greatly improved but the yield of manure (seet water and *seet*) will be greatly increased also (from 50 to 100 per cent.). Thus the lands can be more intensively manured for other crops which follow indigo. The experiments at Pusa and other places in Bihar have shown that by proper manuring with super and green manure, the output of other crops, especially cereals, can be doubled in a few years (*see* the Sapaya results above) or even trebled. The more *seet* there is available the higher too will be the rent which can be demanded for lands let out to *raiyats*.

If at the present time crops other than indigo largely pay the costs of working the estate, the increased yields of such crops caused by manuring should be clear profit which would enable the indigo itself to be sold at a cutting rate to keep down competition of the synthetic. It must be clearly borne in mind that the

indigo is grown not merely for itself but largely for its effect in enriching the soil by the direct assimilation of nitrogen from the air and by its providing large supplies of *seet* which greatly enhances the value of the land by its manurial qualities.

That the above picture of the cumulative advantages of phosphate manuring is not a fanciful one but is capable of certain realization is clear from the actual history of agriculture. In fact the position of Bihar to-day appears strikingly similar to that of England nearly a century ago. Large towns were then growing up and the continual removal of crops and dairy produce, especially the latter, to the towns, rapidly impoverished both soil and pasture. The introduction of the manufacture of superphosphate by Sir John Bennet Lawes shortly after 1845, had a marvellous effect on fertility throughout the whole country and on the yield of dairy produce. Not only was the pasture land revived by the *direct* action of the phosphate but far larger crops were obtainable from arable lands, especially root crops, and it thus became possible to keep more cattle. These indirectly helped fertility (especially in the case of cereal crops) by supplying larger stocks of farmyard manure, and a rapid improvement of the soil became general throughout Great Britain.

That similar surprising results have followed the use of superphosphate wherever the soils are naturally deficient, is also a matter of history. The writer, when working at the Rothamsted Station, has been repeatedly assured by visitors from Australia that probably the principal factor in the prosperity of Australian agriculture has been the introduction of phosphatic manures there, which by increasing the fertility of the soil made it possible enormously to increase the number of sheep and cattle reared in that country and so at the same time greatly to increase the output of wool. Here again the effects of the making good of one single deficiency in the soil, reacted cumulatively in half a dozen directions and so greatly increased the general wealth of the community. To the writer it seems certain that similar advantages would accrue from the widespread adoption of phosphatic manuring in Bihar.

The penalty of procrastination.

The time factor is an important one in the coming struggle between natural and synthetic indigo. If proper manuring trials be not immediately instituted it appears certain that in the next few years the indigo crops throughout Bihar will fall off in an alarming way. The kind of thing to be expected can be judged from the actual example of Belsand—where in the four years between 1908 and 1912 owing to the spread of "wilt," the output of indigo fell from 604 maunds to 220 maunds on a slightly increased area. Recently several cases have been reported to me of the complete failure of August and October sowings at an early stage of growth. One of the most interesting is that of a field which was sown during the rains (July 1917) for a Java seed crop. The seed germinated well but after the plant had reached a height of 6″ it became diseased and gradually died out—it never reached a height of more than 18″ and by October nothing was left but thin sticks. The land was then harrowed and re-sown in October for a Java manufacturing crop. Again the plant germinated well but the small plant soon became diseased and largely died out. The land was then re-sown with Sumatrana plant early in March: again there was a good germination but by the end of March the plant had again completely failed. Here three successive sowings of indigo which germinated well died out after reaching the height of a few inches. I have met numerous similar cases in different parts of Bihar. Fields which several years ago gave good yields of indigo now fail to give crops at all—or poor, diseased and stunted crops. Last year (1917), as already pointed out, owing to the general failure of *khoonties*, the yield of indigo in Bihar fell off by 17 per cent. as compared with 1916.

It is certain that possible improvements in **manufacture** alone—although these are very considerable—can effect relatively small increases in total yield unless attention is also given to remedying the exhaustion of the soils. This is obvious from the fact that if the crop falls to about one half during the next few years—and at Belsand the actual falling off in four years was 65 per cent.—any large increase (say, even 40 per cent.) in output which can be

effected in the future by improved methods of manufacture will, on the *half crop remaining,* fall very far short of balancing the enormous loss in the crop itself—in fact there will still be a loss of 30 per cent. as compared with the present yield per acre, using the present unimproved methods of manufacture. On the other hand, if the crop were increased by manuring by 100 per cent.—and I consider such an increase could be realized in a few years—and at the same time a 40 per cent. increase in yield of produce were practicable on the *increased* crop, the total indigo produced per acre would be increased nearly threefold. This is clear from the following numbers :—

> Present crop per acre taken as 100 yielding only 70 parts of its indigo.
>
> Present crop doubled by manuring as 200 yielding with improvements the whole of its indigo, 200 parts.

Unless estate manurial trials be started immediately it appears to me certain that the next few years will witness a very large falling off in the output of natural indigo. This will happen at the time when competition with the synthetic is most severe and it is most important to have a large output in order to be able to sell at a low price to compete. Unless proper phosphate manuring be adopted—and that rapidly—the natural dye will be seriously handicapped in the next few years and its final extinction rendered certain.

Eighteen months ago I pointed out the relationship between the phosphate deficiency of the soil and the wilt disease of indigo in Bihar and have since been constantly advocating the necessity of superphosphate as a manure. With a few exceptions, planters have, however, as yet, not made up their minds to carry out manurial trials on their own estates—each one apparently is waiting to see what his neighbour does. In this case time is precious—the superphosphate acts slowly as a rule, and if competition with synthetic is to be met in the near future, each planter must *make trials* to ascertain which fields on his estate best respond to treatment with superphosphate, so as to be in a position to take up manuring on a large scale within the next few years. If the industry is to be

restored a considerable outlay on superphosphate manures will be required in the next few years. The large profits realized by indigo estates since the war should facilitate such an outlay: it remains to be seen whether the remedy will be taken in time.

(To be continued.)

RAINFALL, IRRIGATION AND THE SUBSOIL WATER LEVEL OF THE GANGETIC PLAIN IN THE UNITED PROVINCES OF AGRA AND OUDH.

BY

C. H. HUTTON, M.I.C.E.,

Lately Chief Engineer, P.W.D., Irrigation Branch, U. P.

[Continued from vol. XIII, page 205.]

II. THE WELL-IRRIGATED TRACT.

TABLE I (vol. XIII, p. 204) shows the agricultural and irrigation statistics of this tract for the famine years of 1896-97 and 1907-08 corrected in the manner already explained to show the total area irrigated during the year.

The total area irrigated in 1907-08 shows an increase of 32·3 per cent., it was 31·2 per cent. of the total cropped area of the year and 35 per cent. of the normal cultivated area. The corresponding figures for the same year for the canal tract were 50·6 per cent. of the total cropped area of the year and 56 per cent. of the normal cultivated area, figures which show how much better protected against famine this latter is. Except for some small areas in Muttra and Cawnpore and a considerable area in Agra, Fatehpur, and Allahabad, the canal tract is completely protected against famine, whereas the well tract is not so. Wells in numbers can do much to mitigate the effects of a famine, but they cannot save the *kharif* crop and the cattle give out under the stress of constant irrigation.

Comparing the *ek-fasli* figures for irrigation from wells and other sources it will be seen that well irrigation in 1907-08 shows

the remarkable increase of 49·4 per cent. due to the great increase in the number of wells since 1896-97 ; on the other hand irrigation from other sources shows a decrease of 19·3 per cent. due to poorer supplies in the *jhils*.*

The *ek-fasli* area irrigated per well in use in 1907-08 was just 3 acres.

The alluvial deposits of sand and clay underlying the Gangetic plain are of unknown depth ; they have been proved by borings at Lucknow to a depth of over 1,000 feet.

The subsoil strata may roughly be said to contain 33 per cent. of open pore space which below the water table is filled with water : this will, however, yield to pumping about 25 per cent. only, as a certain percentage clings to the particles of silt and sand and cannot be dislodged by gravity.

The total area of well irrigation in this tract in the famine year of 1907-08 was the maximum hitherto recorded, *viz.*, 2,100,000 acres approximately ; the total area of this tract is in round figures 12,800,000 acres, about six times as great.

If the depth of water used in well irrigation be taken as 8 inches, a full average for three waterings, this depth is equivalent to a depth of only 1·3 inches when spread over the whole area ; in other words, the draught on the wells, if considered equally distributed over the whole area, would have lowered the ground-water level about 5 inches.

In the absence of any artesian action the rainfall over this tract must be the sole source of supply of the ground-water. Pilibhit, however, in the north of this tract, no doubt receives some contribution through seepage from the rainfall on the area to the north of it which eventually finds its way to lower levels.

The mean annual rainfall of this tract is 38·60 inches, and, as will be shown later, about 12 inches of this percolates through the upper strata of soil to raise the ground-water level, which from what has been already stated would raise the level about three feet. As to how much this is reduced by seepage during the year is quite unknown ; it is clear, however, that the effect must be

* Natural depressions in which water accumulates during the rains.

considerable and sufficient to keep the subsoil water level within certain limits in spite of the low velocity of underground flow.

Surface evaporation would appear to play no part except where the water table rises to near the surface, for 7—10 feet appear to be the limit of capillary action even in certain fine soils.

The above figures, even if only approximately correct, as it is believed they are, show that the draught on the subsoil water even in a famine year is but a small fraction of the increment of percolation from the mean rainfall, and that therefore the subsoil water supply is for all practical purposes inexhaustible.

It is not contended, however, that excessive draught on the underground water within limited areas might not result in a permanent lowering of the water table.

The Amritsar pumping scheme is based on this expectation. This work which will shortly be put in operation will be the first serious attempt in this country to correct by pumping from tube wells, sunk from 100—200 feet below ground, an undesirably high spring level over an area of some six square miles due to the combined effects of seepage from the canal and over-irrigation : the water thus pumped will be used for irrigation instead of water from the canal.

This work should afford valuable information as to its effect on the water table in view of the further extension of power pumping from tube wells in the near future. These in Oudh are so few in number at present, and each of the comparatively shallow percolation wells abstracts so small an amount from the underground supply, that, even in limited areas, we appear to be within no measurable distance of the time when the increase in the number of such wells is likely to lead to a permanent fall of the water level to so serious an extent as to affect their working, and we must therefore look for other reasons for the continued fall in the subsoil water level in recent years, which has been the cause of considerable anxiety amongst the cultivators of Oudh.

The first mention in the Season and Crop Report that the subsoil water level had fallen to a serious extent occurs in the year 1908-09. In 1909-10 and 1910-11 there were no complaints ; in 1912-13 it is stated that the fall continues and, in the words of the

Commissioner of Lucknow, "threatens to be a very serious calamity"; in 1913-14 it is stated, "the dry season and urgent demand for water for irrigation purposes brought into prominence the falling of the water level in parts of Oudh. It is reported the districts most affected are Unao, Sitapur, Hardoi, Lucknow, and Kheri, and to a lesser degree Partabgarh and Sultanpur. Further, that the fall is more marked in particular areas than in others, *e.g.*, in a comparatively limited area round the town of Safipur in Unao District the fall was not less than 8—10 feet, while in the adjoining country it was insignificant and not sufficient to render the wells unserviceable. The same feature was noticed in Sitapur District and also in Hardoi."

It is of course a matter of common knowledge that the water level rises quickly after a year of good rainfall but falls slowly after a year of bad rainfall. Of the total annual rainfall, part is lost by direct evaporation from the surface of the soil, part by the transpiration of trees and plants, part by the interception of trees and plants, and a varying proportion of the balance, dependent on the moisture content of the soil, percolates under the forces of gravity and capillarity through the upper stratum of soil into the subsoil. One of the effects of this movement of water is to raise the subsoil water which slowly finds its way to lower levels. The rate of flow of seepage and underground water depends upon a number of factors, the chief of which are : (1) the available head or gradient; (2) the relative porosity of the soil; and (3) the temperature of the soil and water. According to Prof. C. E. Schlichter, an American authority on the subject, the velocity is only one-tenth of a mile per annum in a fine sand with grains of 0·20 m.m., having a porosity of 32 per cent., and a temperature of 50°F. under an hydraulic gradient of 100 feet per mile. French engineers are agreed that, even in coarse water-bearing sand, the velocity of flow does not exceed one mile per annum. It is clear that in Oudh with a much flatter hydraulic gradient than 100 feet per mile the movement of ground-water is extremely slow. In considering the question of the ground-water supply and levels it is very important to have some idea of what proportion of the normal rainfall reaches the subsoil to replenish the ground-water supplies,

EVAPORATION AND DRAINAGE.

The only records of any observations made in India that have been published, as far as I am aware, are those described in the Records of Drainage in India by Dr. J. W. Leather,[1] from which the following facts are abstracted. The observations at Cawnpore with two drainage gauges six feet deep, the surfaces of which were maintained fallow but not allowed to become compacted, furnish us with some idea of what proportion of the annual rainfall percolates through the good, well-cultivated soil of the Indo-Gangetic alluvium.

As a result of five years' observations, 1904-08, with an average annual raintall of 31·4 inches the drainage was 12·3 inches or 38·2 per cent. and the evaporation 19·1 inches or 61·8 per cent. In 1903-04 when the rainfall was highest, *viz.*, 46·51 inches, the drainage was 21·25 inches and the evaporation 25·26 inches; in 1904-05 when the rainfall was lowest, *viz.*, 20·61 inches, the drainage was 3·14 inches and the evaporation was 17·47 inches, figures which show how much the percolation depends on the rainfall and that, as Dr. Leather states, the amount which evaporates during the 12 months at any place is almost constant or at least varies in only a subordinate degree and is generally highest in a wet year, conclusions which are confirmed by similar observations in England. Since the whole of the rainfall was impounded on the surface of these gauges the results do not take into account the surface flow off the ground which takes place, to a limited extent, even in a monsoon of low rainfall of which the increased supplies in the local rivers, streams, and *jhils* are evidence. The results, therefore, for both evaporation and drainage, especially the latter, are undoubtedly in excess and require correction to allow for surface flow-off. The above results are for gauges kept fallow and it is necessary, since any tract of country is partly under crops, trees, or grass, to consider the effect of cropping, for it is evident that the quantity of water found to be evaporated from fallow soil will be less or greater than that evaporated and transpired from that under crops, according as the effect of protection is less or greater than transpiration.

[1] *Mem. Dept. Agr., India*, Chem. Ser., vol. II, no. 2.

According to Dr. Leather, the effect which crops have on the amount of drainage and evaporation is the result of several factors, *viz.*—(1) the amount of water transpired depends largely on the weight of the crops : each crop has a transpiration ratio peculiar to itself, but the variations in the magnitude of such ratios are generally small compared with the differences in the weight of the crops; (2) a growing crop protects the soil moisture more or less from evaporating into the air ; the normal circulation of the air over the soil is retarded and the air within the crop is thus maintained in a highly saturated condition, at the same time the plant reduces the amount of water in the surface soil. The observations on the cropped gauges, both at Cawnpore and Pusa, are too few in number to draw very definite conclusions from, but, as far as they go, they indicate that the effect of a crop is to reduce the evaporation of the soil and that a good crop, while transpiring large amounts of water, reduces the loss of moisture by evaporation from $\frac{2}{3}$ to $\frac{1}{2}$ of that from fallow land.

SURFACE FLOW-OFF.

The annual flow off a catchment is most difficult to estimate as it depends on so many factors, *viz.*, the amount and duration of the rainfall, especially the hourly rate of fall, the condition of the ground when the rain falls, the season of the year, the area and configuration of the catchment area, the character of the soil, and the cultivation and cropping of the land.

For the well tract under consideration the run-off in a year of average rainfall might be 15 per cent. of the monsoon rainfall and in a year of minimum rainfall only 5 per cent. of the same. The only method, however, of ascertaining with any degree of accuracy the loss by seepage and the surface flow-off from any catchment would be extended gaugings of the streams which drain such catchments.

INTERCEPTION.

There are no data available of the amount of the rainfall lost by interception of trees and growing crops and evaporated without ever reaching the ground. Probably some 10 to 15 per cent. of the rainfall is ordinarily so intercepted. If sufficient data existed it

would be possible to make an estimate of the amount of the various losses for this particular tract; out of a gross area of nearly 12,833,000 acres, about 410,000 acres are under forests and groves, 1,900,000 acres are designated as not available for cultivation, mostly under grass or scrub jungle, 3,000,000 acres are cultivable waste, also mostly under grass or scrub jungle, and the balance of 7,523,000 acres represents the normal cultivation, this latter at different periods of the year is either under crops or lying fallow and may be tilled or untilled.

Evaporation and Transpiration Losses.

There are no data as to the evaporation or transpiration losses of an area under forest trees. Generally transpiration losses are very large, but owing to mulch, shading, and protection from wind, direct soil evaporation is small. Probably the best estimate of water losses by transpiration could be made from direct observation as to the state of development of the crop or the amount of dry matter developed. A determination of the transpiration losses by this method involves three factors: (1) the area covered by a given kind of vegetation; (2) the transpiration depth per unit or crop yield; and (3) the average crop yield per acre.

The data for (1) and (3) for any year can be obtained from the statistics of the Agricultural Department. Data as to transpiration losses in terms of crop yield are very few at present. This method of estimating transpiration losses is admittedly approximate, but has at least the merit of being founded on matters capable of direct observation.

Little information is as yet available as to the evaporation from soil under crops; this too must vary with the degree of cultivation. The fallow surfaces of the Cawnpore and Pusa gauges were untilled, and the results for surface evaporation are of course higher than for tilled soil; in the case of this latter too surface flow-off would be diminished while drainage would be increased.

The evaporation loss from a soil surface, according to Horton, is the product of two factors, evaporation rate and evaporation opportunity, this second being a term involving the degree and duration of moisture in the soil. In general the evaporation

opportunity is less than unity and consequently the evaporation loss from a soil surface is less than that from a free water surface subject to the same conditions of evaporation rate. He also states that most existing evaporation formulæ are in error in that they involve a linear factor for wind correction such that wind effect apparently increases indefinitely as the wind velocity increases. He states that it has been proved experimentally and is moreover indicated by physical considerations that, since the wind can do no more than remove the water vapour as fast as it is emitted from a water or soil surface, there is a maximum or limiting value of the wind factor corresponding to each surface temperature, and that apparently this value corresponds to a wind velocity of about 15 miles per hour. The data regarding evaporation from soil surfaces in this country are at present too few to frame any fairly close estimate thereon.

The following figures as to the disposal of the mean rainfall of this tract are given by me with some diffidence but after a study of such data as are available.

	Inches
Surface flow, 15 per cent. of the *kharif* rainfall of say 37 in.	5·5
Interception	1·5
Evaporation	15·0
Transpiration	4·5
Drainage	12·1
Total	38 6

It may, I think, be stated with some confidence that the drainage is between 10 and 14 inches. In 1907-08 only 54 per cent. of the normal rainfall was recorded or 20·84 inches. As already stated the quantity evaporated is nearly independent of the rainfall and the following figures give some idea of its disposal.

	Inches
Surface flow, 5 per cent. of *kharif* rainfall	1·0
Interception	1·0
Evaporation	15·0
Transpiration	4·0
Drainage	..
Total	21·0

It is fairly evident that in such a year not only was there no drainage, but there was also some reduction in the moisture content of the upper strata of soil which is in accordance with fact.

The figures given are but approximate, based on the best data available, but, considering the large number of various factors involved, probably a more satisfactory method of ascertaining what proportion of the rainfall percolates to raise the ground water level would be to select a certain number of the non-irrigation wells outside the influence of the canals and at which the water level has been observed for some 30 years, and to endeavour to correlate the rise of the water level between the May and November observations with the rainfall: the fall between the November and May observations would indicate for this period the effect of the subsoil flow. I regret I have not with me the necessary data to attempt this.

Table II shows the mean annual rainfall, together with the variations from the mean for each year from 1901-02 to 1915-16 for each district in the tract under consideration: it shows that from 1901-02 up to 1914-15 the annual rainfall was rarely and then but slightly above the mean, that it was frequently in considerable defect, and that it was not in any considerable excess until 1915-16: it also shows that the total deficiency up to 1913-14 amounted in most districts to a year's mean rainfall and in a few districts, *e.g.*, Pilibhit, Unao, Sultanpur, Hardoi, and Kheri to considerably more than this. The period of greatest deficiency was from 1905-06 to 1908-09.

For this tract as a whole (*vide* Table III), the deficiency was so great in two consecutive years, *viz.*, 54 per cent. of the mean in 1907-08 and 65 per cent. in 1908-09, that it is probable that the rainfall contributed little, if anything, to the subsoil water supply: while at the same time, the water level was being steadily lowered by seepage into the rivers and streams and also, but to a much smaller extent, by the steady draught of water for irrigation from wells, *jhils*, and streams.

If all these facts be taken into consideration it is not surprising as the result that there has been in recent years, *viz.*, from 1908-09 up to 1914-15, a considerable and more or less continuous fall of the subsoil water level over the whole of this well tract.

The whole of this well tract is remarkable for the large number of *jhils*, either shallow and isolated depressions, or chains of such

Table II.

District	Normal rainfall	Variation from normal rainfall																
		1901-02	1902-03	1903-04	1904-05	1905-06	1906-07	1907-08	1908-09	1909-10	1910-11	1911-12	1912-13	1913-14	1914-15	1915-16	1901-02 to 1913-14	1905-06 to 1908-09
Shahjahanpur	36·72	–0·02	–9·82	+8·68	–1·22	–12·15	+1·10	–7·10	–11·03	–1·05	+8·63	–2·35	–5·02	10·28	+3·00	+14·57	–41·63	–29·18
Pilibhit ..	50·03	–1·33	–2·93	+3·27	–3·23	–12·54	–10·33	–21·24	–4·66	+8·86	+11·21	–7·10	–7·95	–25·86	–0·67	–5·48	–73·83	–47·34
Lucknow ...	35·66	–5·46	–8·06	+6·44	+5·44	–6·37	+10·00	–20·19	–5·64	+8·48	–5·16	–3·60	–3·45	–6·97	+1·72	+33·44	–34·54	–22·20
Unao ...	33·59	–5·29	–7·59	+2·71	+15·51	–12·89	–2·93	–16·27	–12·15	+2·71	–2·45	–5·17	–7·22	–12·58	–3·71	+28·43	–63·62	–44·24
Rae Bareli ...	36·27	–8·37	–4·17	–0·87	–2·47	–11·36	+0·56	–14·90	–10·12	+6·78	+4·28	+2·12	+3·23	–5·92	+0·17	+12·11	–41·21	–35·82
Partabgarh ...	37·66	–6·36	–1·96	+17·84	–1·66	–3·91	–3·01	–7·73	–14·15	+9·70	+7·21	+1·82	–5·25	–5·87	–2·48	+13·39	–13·33	–28·80
Sultanpur ...	41·23	–14·63	–7·53	+13·67	–7·93	–4·12	–4·45	–21·13	–20·11	+4·26	+2·28	+3·37	–10·42	–9·28	+2·78	+14·65	–76·02	–49·81
Sitapur ...	36·81	–0·71	–1·91	+1·49	+2·39	–3·41	+0·74	–19·09	–15·66	–1·35	+4·85	+0·43	+1·20	–9·10	+10·10	+29·45	–40·15	–37·42
Hardoi ...	34·78	–2·98	–5·78	+4·32	+7·82	–13·09	–2·11	–20·21	–16·03	–1·90	–3·42	–7·56	–2·28	–12·67	–3·83	+17·01	–75·89	–51·44
Kheri ...	43·59	–5·49	–11·79	–0·69	–0·69	–12·83	–4·50	–26·89	–17·80	+3·43	+7·76	–6·16	–8·85	–16·56	–0·32	+13·27	–101·09	–62·02
Barabanki ...	38·27	–7·87	–2·67	+8·53	–2·37	–12·35	+6·48	–20·35	–19·52	+25·81	+8·01	+4·08	+1·20	–12·57	+12·52	+27·20	–43·57	–45·72

Table III.

	Normal rainfall	Percentage of normal rainfall														
		1901-02	1902-03	1903-04	1904-05	1905-06	1906-07	1907-08	1908-09	1909-10	1910-11	1911-12	1912-13	1913-14	1914-15	1915-16
Canal tract	30·14	73	89	102	115	54	110	57	104	105	111	84	98	60	119	92
Well tract .	38·60	86	85	115	103	74	98	54	65	111	110	95	89	70	106	147

separated from each other by high necks which are overtopped only in a good monsoon : these depressions are largely resorted to for irrigation.

In the dry year of 1899-1900 the total irrigation from "other sources," *i.e.*, *jhils* and streams, was 842,137 acres ; in the famine year of 1896-97 the area so irrigated was 439,891 acres, and in that of 1907-08, 354,868 acres ; these figures show that the available supply from other sources, chiefly *jhils*, was considerably less in this latter year.

This well-marked feature of this tract has, without doubt, a considerable influence, especially locally, on the subsoil water level. One of the benefits which result from the construction of reservoirs and tanks in Bundelkhund is a general rise of the water in the wells in their proximity, and there is not the least doubt that these depressions when holding water have the same local effect and that their wide-spread distribution accounts in a large measure for the somewhat high subsoil water level over many parts of Oudh.

In years of light rainfall the surface flow-off is but small or even nil, and in consequence these depressions are not filled, and, moreover, soon after the close of the monsoon they are quickly emptied by irrigation : the effect of such seasons on the subsoil water level, more particularly in the areas around these depressions, is considerable, and the same effect would be realized when these *jhils* are drained in order to reclaim the land to cultivation as has already been experienced at Safipur where the considerable fall in the level in a comparatively limited area must be due to drainage operations on the top of a series of years of short rainfall. The fall of the subsoil water level in Oudh in recent years and which has been more particularly marked in limited local areas is thus sufficiently accounted for.

The monsoon rainfall of 1915 was very heavy, *viz.*, 47 per cent. in excess of the mean, and in consequence it is reported that the *jhils* were filled to overflowing and the subsoil water level not only rose to its former level but beyond it.

A word of caution is here necessary anent the Sarda Canal which it is proposed shall be brought into this tract. As an

argument in support of it the statement has been made that the water level generally in Oudh is not as high as had previously been supposed. Undoubtedly, as a result of a series of years of short rainfall, the ground-water level has been falling and about 1914-15 it was probably at its lowest for many years past; this, however, affords no reason for doubting the correctness of the recorded observations of Major Forbes and Mr. King. It is evident that the ground-water level is subject to considerable fluctuations dependent on the season's rainfall.

The introduction of the Sarda Canal into this tract will tend to raise the water level. This tendency can be counteracted by keeping the canal bed above the clay sub-stratum wherever this exists and by puddling the canal channel elsewhere, also by efficient drainage measures: the natural drainages must be improved and artificial drains constructed to drain the large number of *jhils* of their contents, which are responsible in no inconsiderable degree for the generally high level of the subsoil water throughout Oudh: such drainage, moreover, will reclaim to cultivation thousands of acres of good land which can be irrigated from the canal.

In conclusion, it has been shown that the marked and more or less continuous fall of the subsoil water level in Oudh between the years 1908-09 and 1914-15 was undoubtedly due to a series of years of deficient rainfall, and that in two consecutive years, *viz.*, 1907-08 and 1908-09, little, if any, of the rainfall could have percolated to the ground-water table. It has also been shown that the draught for irrigation on the ground-water, even in a year of severe drought, is but a small fraction of the increment received from the mean annual rainfall, and, therefore, if we average the present draught over a series of both wet and dry years the effect in the direction of causing a permanent fall in the water level must be very small indeed, and there appears to be no reason on this account to call a halt in the further construction of wells.

Finally, from what has been stated above, it is clear that there are many problems connected with seepage from canals and the ground-water level which await investigation.

LAND AND LABOUR IN A DECCAN VILLAGE*: A REVIEW.

BY

THE HON. MR. G. F. KEATINGE, C.I.E., I.C.S.,

Director of Agriculture and Co-operative Societies, Bombay.

SUCH endless discussions have taken place in the past regarding the exact economic situation of the Indian cultivator, and so many divergent views, based on general statistics, vague information and personal opinion, have been expressed on the subject that it is very refreshing to find an attempt being made to record the exact economic details of a single, typical Indian village. Such an attempt has been made by Dr. H. H. Mann, Principal of the Poona Agricultural College, and three of his assistants, and recorded in a publication issued by the University of Bombay. The enquiry is thorough and detailed, and the record illustrated by maps, diagrams and photographs which add considerably to the interest of the book from the point of view of the general reader.

The first two chapters deal with the physical features of the village, the climate, geology, soils and waters, which are typical of a large tract in the Bombay Deccan. The account given of these matters is clearly expressed and cannot fail to be of interest to any one belonging to this locality, while the information regarding such matters as soil-formation and subsoil water are of considerable value to all for whom these subjects have more than a passing interest.

Chapter III deals with the land and its divisions, giving an account of the holdings, *inams*,† and revenue history of the village from

* By Harold H. Mann, D. Sc., and others. Oxford University Press. Price Rs. 2 or 3*s* 6*d*.

† A form of land tenure which carries partial or complete exemption from the obligation to pay revenue.

1700 to the present day, showing how large a part of the revenue was alienated to individuals and temples, and for presents, festive occasions, and charity in the olden days when the Peshwas were able to draw large revenues from other parts of India. In the present day there are 140 holdings, aggregating 1,006 acres, assessed at a total of Rs. 1,660. Perhaps the most remarkable figures in this chapter are those which show how the holdings have become sub-idvided under the existing laws of inheritance, as the population has increased. In 1771 the average size of the holding was 40 acres. By 1818 it had fallen to 17½ acres. From 1820 to 1840 it remained constant at 14 acres, and by 1915 it has been reduced to 7 acres. Of the total number of holdings 81 per cent. are now under 10 acres in size, and 60 per cent. under 5 acres. Further, these holdings have been fragmented into 729 separate plots of which 463 are less than an acre, and 112 less than ¼th acre.

The actual farms, as now separately cultivated, consist of 109 holdings in 741 separate plots; which means that the average farm, as cultivated, consists of 9 acres, broken up into 6 or 7 plots.

Now what results might be expected from such conditions? On general principles it would be extremely probable that these holdings, subdivided below the economic limit and greatly fragmented in addition, would be badly cultivated, and that no permanent improvements or progressive development of the land could be secured. This is, in point of fact, exactly what we find. There is a river in the village containing perennial water of good quality, which would readily lend itself to irrigation, and also two large *nalas** which contain water for some time after the monsoon. The water of these is not used at all for irrigation. Eleven wells, built in former times, contain a fair water supply; but even these are little used for irrigation, and the people give as a reason for not making better use of the water, the fact that the land has been so much subdivided, and that the wells usually belong to several co-sharers in what was originally one holding. The damage to the lands by surface scouring and deep gullying in sloping lands is

* Ravines or water courses.

recorded, and it is also noted that very little effort is made to remedy this. To quote the authors' words:—"The limit of effort in this village has been in a few cases to level and embank fields which are actually nearly level, and to divert streams of water, which would be likely to damage the fields, either on to someone else's property or on to the roads and footpaths in the village." No mention is made of any other improvements to the land, and it may be confidently assumed that none have been made. In short, the net result of excessive subdivision and fragmentation of the land has been to preclude all idea of steady development, and, to some extent, to render useless such improvements as were made in times before this excessive subdivision of land had taken place.

The nature and condition of crops are dealt with in the next chapter. As might be expected from the economic conditions, the situation is anything but satisfactory. There is little intensive culture, few valuable crops are grown, and the out-turn of the crops grown is very poor. *Jowar* (*A. Sorghum*) and *bajri* (*Pennisetum typhoideum*) are the main crops produced. Indeed in 1913-14 no less than 770 acres were under these two crops out of a total cultivated area of 874 acres. The more valuable crops grown are wheat, carrots, peas and groundnuts; while sugarcane is occasionally grown in very small areas. As regards gross out-turns it is estimated that on fair lands *jowar* gives Rs. 31 per acre, *bajri* Rs. 21-8-0, wheat Rs. 30-2-0, and groundnut Rs. 50-12-0, and that in order to get the general average, even in good years, a reduction of from 10 to 20 per cent. must be made. The figures given below compare the out-turns obtained on the Government farm at Poona, under similar conditions, with those estimated for this village:—

Value of out-turn per acre.

	Obtained by the *villagers* Rs.	As.	Obtained on the *Government farm*	Rs.
Jowar	... 24	13	Kharif	55
			Rabi	80
Bajri	... 17	4		38
Wheat	... 24	2		53
Groundnuts (Pondicherry)	...	11		90

The out-turns on the Government farm are secured by methods of clean cultivation, timely operations, and proper rotations. They represent the actual average for 5 years, taking good and bad years alike. It must therefore be conceded that the results obtained in the village are very poor, since they represent in every case less than half the out-turns obtained on the Government farm. It is also a remarkable fact that in the village the cultivators make no attempt to cultivate cotton, chillies, or onions, which on the Poona farm have given the profitable results shown below :—

	Value of out-turn. (5 *years' average*)
Cotton ...	Rs. 74
Chillies (unirrigated) ...	Rs. 192
Onions (irrigated for 3 months) ...	Rs. 177

Perhaps the most interesting chapter, however, is Chapter VI, where under the heading "The People" the authors calculate the income of the village and draw their conclusions as to the solvency, standard of living, and general well-being of the population.

It is to this that the whole of the argument works up, and it might have been hoped that this part would have been clearer and more explicit than it is. On page 137 is given what is described as the "balance sheet" of the village; but in point of fact it is nothing like a balance sheet, and is not complete or very intelligible even as a "Profit and Loss Account" which is apparently what it aims at being for 103 out of 111 families in the village. This is a pity, because the details given in the book are sufficient to construct a rough "Profit and Loss Account" for the village, which would direct attention to some of the most remarkable features in the economy of the village, which are now completely obscured. The "Profit and Loss Account" for the village for the year 1915-16

works out as follows on the basis of the figures recorded in the book :—

Profit and Loss Account of the village for the year 1915-16.

Profit—	
Total value of ordinary crops	Rs. 18,720
Value of produce from fruit trees and *babul* (*A. arabica*)	Rs. 409
Value of dung cakes prepared	Rs. 1,200
Value of milk produced	Rs. 4,866
Value of *gul* (raw sugar) made	Rs. 3,780
Gross income from land	Rs. 28,975
Wages earned outside the village	Rs. 13,503
Total	Rs. 42,478

		Loss—
Land Revenue		Rs. 1,660
Seed		Rs. 1,233
Cost of feeding cattle		
(*a*) 108 bulls and bullocks, at Rs. 60	Rs. 6,480	
(*b*) 80 calves at Rs. 20	Rs. 1,600	
(*c*) 96 cows and she-buffaloes	Rs. 4,866	
		Rs. 12,946
Money leaving the village on account of wages for cultivating sugarcane and making *gul* (say)		Rs. 2,000
Total outgoings		Rs. 17,839
Net annual profit of the village		Rs 24,639
Total		Rs. 42,478

The totals arrived at in this way are substantially the same as those arrived at in various parts of the book, and the only difference is that whereas in the book the method by which the net profits were arrived at is not explained, the Profit and Loss Account given above indicates the method by which the calculation is made. In view of the smallness of the holdings and the superabundant labour in the village, it has been assumed that all the labour used in producing the crops is labour of the village, except in the case of sugarcane for which it is specifically stated that outside labour is always employed, and for this a debit has been made. The only item entered above which seems to be doubtful is Rs. 4,866 as the cost of feeding the cows and buffaloes. This figure is the same as the value of the milk said to be produced in the village. No credit for the value of the milk was made in the so-called balance sheet on page 137, and it is therefore assumed that the cost of feeding and the value of the milk produced are held to balance each other. The omission of any credit entry for milk may have been an oversight, but in any case the net profit would not have been large, and the argument remains substantially unaltered. It may also be remarked in passing that the area cultivated in 1915-16 was less by 121 acres than the normal

(*vide* page 67), so that in an ordinary year some Rs. 2,000 would have to be added to the net profits of cultivation in the village.

The authors call attention to the very small gross return per acre, and this point deserves all the notice that they give it; but what is even more remarkable is the fact that the cost of maintaining the bullocks and young stock amounts (at a very moderate computation) to Rs. 8,000, a figure which is nearer ½ than ⅓ of the total value of the crops. In other words, under the existing system the maintenance of the work-cattle is a dead-weight on the industry which economically it cannot support. This is a matter of prime importance and denotes a problem to which the old books on French farming all refer; but it is impossible to enlarge on the subject here.

An even more surprising result is obtained by comparing the earnings from cultivation in the village with the earnings from sources other than cultivation. Apparently 119 men and 2 women who engage in non-agricultural labour can, working without capital, earn Rs. 13,503 in the year, which amounts roughly to Rs. 9-4-0 apiece per mensem. Considering the current rates of wages in Poona, Bombay, and the adjoining canal tracts, this is a distinctly low average. But when we turn to the agriculturists what do we find? Apart from those who work outside the village there remain 76 men, 198 women, and 166 children (*i.e.*, under 16 years of age). Now assuming that out of these only 60 men, 120 women, and 40 children are capable of work, and that one man is equal to two women or children, this leaves 140 male units for the village. These earn Rs. 11,136 in the year, which works out at only Rs. 6-8-0 per mensem, assuming that they are working without any capital. But we are told that they are working with a capital of Rs. 93,588 (excluding houses). If we assume that they are content with 5 per cent. interest on working capital, this means that from agriculture each man is earning rather less than Rs. 4 per mensem. If on the other hand we take the rate of interest which in the Deccan is current for loans made on good security, *viz.*, 12 per cent., we find that the agriculturists are making absolutely nothing by their labour and

that they would be better off if they sold their land, cattle and implements, invested the proceeds and sat completely idle.

Now what is the meaning of the apparent paradox that the cultivators are content to earn little or nothing by their labour? It is susceptible of two explanations. One is that, in point of fact, the cultivators do earn more than is recorded, and the other is that they have such an easy time playing at cultivating a few acres that they will put up with a bare minimum subsistence for the sake of the ease secured. The true explanation is probably to be found partly in one hypothesis and partly in the other. It would appear very probable that apart from the 121 villagers who are recorded as working for wages outside the village, a certain number do occasional work of this nature and so supplement their earnings from agriculture, and also that in the off-season some money is earned by carting, apart from the four carts which are noted as plying for hire regularly. Further, in view of the fact that the average size of the farms is only 9 acres and that much of the cultivation given is of the poorest description, often consisting of nothing more than harrowing, drilling the seed, and reaping such crop as grows, it follows that the villagers who do no work except on their own land must have a very slack time. This brings us up against what is perhaps the most crucial problem for India. How much work does the average cultivator in any tract do ? What is the efficiency of that labour ? The hours of work and the efficiency of labour vary enormously from one tract to another, and the causes of this variation afford scope for the most interesting study. As regards this particular village it is clear that the standard of work and its efficiency are low. Out of the whole population there are only four men who can, even by courtesy, be placed outside the dead level of unskilled labourers, *viz.*, a gardener, a bricklayer, and two quarry-men ; while the skill and energy of the cultivators may be judged from their unimproved lands, the poor out-turns of the crops, and the fact that they have to depend on outside labour to deal with a small area of sugarcane.

The final conclusion of the authors is depressing, for they maintain that two-thirds of the families in the village are unable

to attain to even the low standard of comfort which is considered essential by the people of such a village. To anyone who knows what such a standard is, this can mean nothing else than that there is actual starvation in the village, or something very like it. Surely this is a matter which would have admitted of actual verification on the spot ; but there is no word to show that any attempt was made, by observing the condition and health of the people, to verify this inference which the figures given so strongly suggest. The low standard of comfort in Deccan villages is deplorably evident even to the most casual observer, but if there is in this village anything like the actual starvation that is implied, this fact is more remarkable than any other which has been recorded ; because it may be stated with confidence that in this village there is no able-bodied family the members of which are prepared to work, which could not, without going 20 miles afield, obtain wages which would not only maintain them in comfort, according to their own standards, but which would also allow them to save money.

VETERINARY RESEARCH: SOME RECENT CONTRIBUTIONS.

IN response to the suggestion made by the Board of Scientific Advice for India that *résumés* of such articles mentioned in the bibliography at the end of the Veterinary Section of its Annual Report as are likely to be of use to veterinary officers in the districts should be published half-yearly, Mr. A. L. Sheather, Director and First Bacteriologist, Muktesar Laboratories, has kindly undertaken to contribute such *résumés*. They will appear regularly in the January and July issues of this Journal.—[Editor.]

GLANDERS.

LANFRANCHI, A.—THE INTRAPALPEBRAL MALLEIN TEST. *Il Moderno Zooiatro*, 1917, No. 9 (Ex. *Bull. L' Inst. Past.*, 1918, No. 2). Original not available.

Lanfranchi has tested a large number of animals by the injection of 2·5 c.c. of mallein subcutaneously into the lower eyelid. He has noted in a number of cases a condition of sclerosis of the lower eyelid, which has necessitated injecting the mallein into the upper lid.

In cases where the result is negative in horses which have been subjected to this method of testing on a number of occasions spread over an unknown period, it is advisable to wait a fortnight before carrying out a fresh test.

EPIZOOTIC LYMPHANGITIS.

LANFRANCHI, A.—THE INTRAPALPEBRAL TEST IN THE DIAGNOSIS OF EPIZOOTIC LYMPHANGITIS. *Il Moderno Zooiatro*, 1917, No. 10 (Ex. *Bull. L' Inst. Past.*, 1918, No. 2). Original not available.

As a general rule, the diagnosis of epizootic lymphangitis presents no difficulty. It may, however, be useful in atypical forms

of the disease to have at one's disposal an experimental method of diagnosis.

Lanfranchi has considered the possibility of applying to epizootic lymphangitis a method resembling the intrapalpebral test by means of which such good results have been obtained in the case of glanders.

The material injected is composed of one part of pus taken from an unruptured lesion and rich in cryptococci mixed with two parts of ether. The mixture is left for 24 hours. The ether is then evaporated off, and the volume made up again with distilled water. This suspension is heated over a water bath to 80° (whether centigrade or fahrenheit is not stated in the French abstract) for 20 minutes. After centrifuging, the supernatant liquid is drawn off. This constitutes the liquid for the test and the dose used is 2½ to 3 c.c.

In infected animals the inoculation is followed at the fourth to the sixth hour by a hot diffuse œdema which increases up to the twenty-fourth hour, and sometimes persists until the fourth or fifth day. A purulent discharge collects, which is in some cases quite abundant.

In animals infected with diseases other than epizootic lymphangitis, the reaction is neither marked nor lasting.

The reaction is more severe in infected animals when the lesions are discrete and have not reached maturity. The local reaction is accompanied by a rise of temperature but no other evidence of systemic reaction.

A primary test does not prevent subsequent tests from being carried out.

A single animal has been successfully tested on six occasions (intervals not stated).

FINZI, G.—COMPOUNDS OF MERCURY IN THE TREATMENT OF EPIZOOTIC LYMPHANGITIS. *Bull. Soc. Path. Exot.*, Vol. X, No. 6, June, 1917.

The author has treated five severe cases of epizootic lymphangitis with mercurial compounds and has succeeded in effecting a cure in every instance.

The following formulæ and methods of application were used :—

(*a*) Six grammes of salicylate of mercury in 100 c.c. of sterile "vaseline oil."

1st day	10 c.c. injected intramuscularly.		
4th ,,	10 c.c.	,,	,,
8th ,,	20 c.c.	,,	,,
12th ,,	30 c.c.	,,	,,
16th ,,	40 c.c.	,,	,,

and subsequently 5 to 7 more injections "of the same dose at the same interval."

(*b*) Five grammes of calomel in 100 of sterile "vaseline oil."

1st day	5 c.c. injected intramuscularly.		
4th ,,	10 c.c.	,,	,,
8th ,,	15 c.c.	,,	,,
12th ,,	20 c.c.	,,	,,

and subsequently 6 to 8 injections at intervals of 3 days and in doses increased by 5 c.c. at each injection unless evidence of intolerance is observed.

(*c*) Perchloride of mercury 1 gramme, sodium chloride 2 grammes, boiled distilled water 100 c.c. This formula was used for hypodermic or intramuscular injection in the same manner as (*b*).

(*d*) Benzoate of mercury 1 gramme.
Sodium chloride 0·26 gramme.
Cacodylic acid 0·5 gramme.
Boiled distilled water 100 c.c.

1st day	20 c.c. hypodermically or intramuscularly.		
4th ,,	20 c.c.	,,	,,
7th ,,	30 c.c.	,,	,,
11th ,,	30 c.c.	,,	,,
15th ,,	40 c.c.	,,	,,

and subsequently 5 to 7 further injections of the same dose at the same interval.

Attention is drawn to the fact that these formulæ must be used with care on account of individual susceptibilities to mercury and variations in absorption. If symptoms of mercurial poisoning are observed oily purgatives must be administered and an interval of 8 to 10 days allowed to elapse before the treatment is re-started. It was found necessary to suspend treatment only in the case of the animal treated with mercury salicylate.

All the animals are reported to have made complete recoveries after 10 to 12 injections. Formulæ (*c*) and (*d*) yielded the most rapid results.

BELIN, M.—THE TREATMENT OF EPIZOOTIC LYMPHANGITIS AND ULCERATIVE LYMPHANGITIS BY "AUTOPYOTHERAPY." *Rec. Méd. Vét.*, Vol. XCII, No. 18, 1917.

In a previous paper the author has published his observations upon the use of a vaccine prepared from pus from cases of epizootic lymphangitis by means of ether. In the present paper he refers again to this method of preparing the vaccine and also describes a method in which heating the pus with boiled water is the essential part. In preparing the vaccine by the ether method pus is collected with every precaution to ensure sterility and this is mixed with about four volumes of ether and shaken vigorously for a couple of minutes. After 18 to 24 hours a similar volume of boiled water is added and the vaccine is ready for use.

The second method of preparing the vaccine is to add to the pus six or seven times its volume of boiled water and to heat this at 70° for about an hour, 0·5 per cent. of carbolic acid being added subsequently. The latter method does not appear to have any advantages over the ether method, and the ether method is simpler to carry out.

The vaccines are said to keep well. Exactly the same procedures may be adopted for ulcerative lymphangitis.

Full details of fifteen cases treated are given.

The injection of the vaccine produces a more or less pronounced negative phase followed by a positive phase.

Although the author succeeded in obtaining cures solely by means of the vaccine, he does not propose to exclude other recognised beneficial treatments, such as evacuating abscesses, etc. His view is that the vaccine should be used in conjunction with such measures. The vaccines appear to vary somewhat in activity, but the author has never obtained an absolutely inactive one. Care must be exercised that pus from young lesions is used.

The injections of the vaccine lead to the formation of small local swellings which subside after a short time.

Successive doses may cause a slight induration which eventually disappears. In one case a small area of necrosis was observed. It is advised that a series of three or four injections of the vaccine in doses of 2 c.c. be first given daily and then a single dose of 2 c.c. weekly. The treatment is stopped when no negative phase is produced by the injection. Emphasis is laid on the importance of making the treatment autopyotherapeutic and not simply pyotherapeutic.

VELU, H.—LOCAL REACTIONS IN THE TREATMENT OF EPIZOOTIC LYMPHANGITIS BY PYOTHERAPY. *Réc. Méd. Vét.*, Vol. XCII, No. 20, 1917.

As a general rule, the injection of the first dose of vaccine produces only a slight œdema at the seat of inoculation which is quite insignificant when compared with the evidences of the negative phase shewn by the lesions.

In some cases, however, hot painful œdematous swellings which may either be absorbed slowly or develop into abscesses occur. Repeated injections may give rise to the formation of small abscesses from which a small quantity of thick creamy pus can be obtained by puncture. Such lesions heal under antiseptic treatment like ordinary wounds, provided they are widely opened. This intolerance increases with each injection. As a rule no organisms are discoverable in the pus, but in some cases cryptococci can be found. This was so in two healthy animals that were vaccinated as a protective measure. This shewed that two months' exposure to ether and

2·5 per cent. carbolised normal salt solution had not sterilized the pus. In such cases, however, the abscesses healed up well and shewed no tendency to develop into typical cases of the disease.

RINDERPEST.

BOYNTON, W. H.—EXPERIMENTS ON THE TREATMENT OF RINDERPEST WITH VARIOUS DRUGS. *Philippine Journal of Science*, Vol. XIII, Sec. B., No. 2, March, 1918.

The publication of the experiments recorded in this paper was considered advisable on account of the numerous claims that have been put forward by persons professing to have discovered cures for rinderpest.

It is noted that in those localities in which successful treatment has been claimed, the normal percentage of recoveries is very high, reaching in some cases 60 per cent. According to the author's general statement, the following twenty drugs have been used: eosin, medicinal methylene blue, cacodylate of soda, atoxyl, quinine sulphate, camphorated oil, creolin, permanganate of potash, ergot, iodine, potassium iodide, gentian violet, adrenalin hydrochloride, nuclein, formalin, chlorazene, castor oil, alcohol, fluid extract of nux vomica, and fluid extract of gentian.

Reference to the details of the experiments shows that in addition to these, salicylate of mercury and cannabis indica were also tried. A few experiments were carried out with anti-rinderpest serum, with a view to testing its curative properties.

In all, some fifty experiments were carried out, and it is stated that "with the small amount of experimentation that has been given to each drug, no promising results have been obtained by the method in which they were administered and the dosage in which they were given."

For intravenous and intraperitoneal injections 0·85 per cent. sodium chloride solution was used, and it was found to be advantageous to warm the solution to 41°C. before injection, the animal showing less discomfort than when cooler solutions were used.

Only two animals out of the whole series recovered, namely, one treated by intravenous injection of 1000 c.c. of 1 in 4000 of formalin, and one by intraperitoneal injection of quinine sulphate. Other animals treated by these methods died. The possibility therefore must be taken into consideration that these animals would have recovered in any case.

TUBERCULOSIS.

GLEN LISTON, W., and SOPARKAR, M. B.—THE SUSCEPTIBILITY OF INDIAN MILCH CATTLE TO TUBERCULOSIS. *Indian Journal of Medical Research*, Vol. V, No. 1, July 1917.

In the opening pages of this paper the authors summarize the references to the occurrence of tuberculosis among cattle in India, and contrast the degree of prevalence among them with the degree of prevalence among cattle in Europe. Attention is drawn to the fact that Indian cattle do not stand alone in showing a low percentage of infection with tuberculosis, a similar state of affairs existing in Japan, Ceylon, and the Malay Peninsula.

In seeking an explanation of the marked difference between the prevalence of the disease in cattle in India and elsewhere, the more open-air life spent by Indian cattle, which has been put forward as the main reason, is discounted to a very large extent when the low incidence of the disease among animals kept in sheds in large towns is taken into consideration.

The experiments detailed in the paper were undertaken with a view to ascertaining whether the relative freedom of Indian cattle from tuberculosis may be due either to natural immunity or to a relatively greater resistance than European or American cattle.

As it was impossible to control the experiments by the simultaneous inoculation of a parallel series of calves from European sources, the results obtained by the English Royal Commission on Tuberculosis in the inoculation of calves were taken as controls.

These experiments indicated that while the subcutaneous inoculation of 50 milligrammes of culture of bovine tubercle bacilli produced almost invariably a fatal generalized tuberculosis, a dose of 10 milligrammes, though often fatal, did not produce generalized disease.

As the bulk of the milk consumed in India is derived from buffaloes, these were subjected to experiment in addition to bovines.

Calves 4 to 8 months old were selected, because the effects of inoculations with tubercle bacilli are more severe in young animals than in adults.

In view of the rarity of tuberculosis among Indian cattle, the animals selected for experiment were not subjected to a preliminary tuberculin test.

The culture used was one received from Eastwood of the Local Government Board, England, in 1915. It was tested for virulence on receipt, and again after subculturing up to the date of the experiments by inoculation into rabbits. Intravenous inoculations of 0·1 and 0·01 milligramme produced fatal generalized tuberculosis in 22 and 25 days.

The culture used for the experiments was from glycerine agar, and it was emulsified in salt solution, so that each cubic centimetre of emulsion represented 5 mgms. of culture.

In the experiments, 11 buffalo calves and 12 bovine calves were inoculated. It was intended to inoculate 12 of each, and keep one of each as controls. Two of the buffaloes died prior to the experiment. One of these had been selected to act as control. One bovine calf was kept as a control.

Six buffalo calves and six bovine calves were inoculated with 50 milligrammes subcutaneously and the remaining animals with 10 milligrammes in the same way.

The clinical history, temperature charts, and *post-mortem* findings of each animal are given.

In summarizing the results obtained, a distinction is drawn on the lines laid down by the Royal Commission on Tuberculosis

between acute generalized tuberculosis and retrogressive tuberculosis, depending upon the extent and nature of the lesions found.

Of the buffaloes inoculated with 50 milligrammes, one died of broncho-pneumonia, apparently not due to the tubercle bacillus, three showed retrogressive tuberculosis at the time of death or slaughter, and the remaining two showed acute generalized tuberculosis.

Of those inoculated with 10 milligrammes, one died of broncho-pneumonia, two of diseases other than tuberculosis, and the remaining two showed lesions of retrogressive tuberculosis.

Of the bovine calves none died of intercurrent diseases. Of those inoculated with 50 milligrammes, three showed acute generalized tuberculosis and three retrogressive tuberculosis. Of those inoculated with 10 milligrammes, three showed acute generalized tuberculosis and three retrogressive tuberculosis.

Apart from the extent and nature of the lesions produced by the inoculations, attention is drawn to the duration of life of the animals after inoculation, this being contrasted with the periods of life of the animal selected from those used by the Royal Commission on Tuberculosis which were taken as controls.

The Royal Commission calves inoculated with 50 mgms. of tubercle bacilli subcutaneously died, or were killed when dying at periods ranging from 18 to 76 days; only one surviving to this maximum, the remainder dying within 47 days.

In the experiments recorded in the present paper the following periods of life were observed in animals inoculated with 50 mgms. Two buffaloes died of acute generalized tuberculosis after 67 and 101 days; three were killed after 125, 128, and 142 days and showed retrogressive lesions only. These three animals had *all* gained in weight during the experiment. Of the bovine calves, three died of acute generalized tuberculosis in 38, 39, and 43 days. The remaining three inoculated with 50 mgms. were killed after 122, 122, and 142 days and showed only retrogressive lesions in *post-mortem*.

Graphic charts are given showing the distribution of the lesions in each of the experimental calves and corresponding calf selected from the Report of the Royal Commission on Tuberculosis. From the experiments the following conclusions are drawn :—

The comparative infrequency of tuberculosis among Indian cattle, whether buffaloes or bovines, is due to a natural resistance to infection rather than to differences in methods of housing, etc.

In view of the fact that some of the Indian calves inoculated even with 10 mgms. of culture died as quickly from generalized tuberculosis as English calves, it would appear that individual susceptibility varies more among Indian than among English cattle.

The question as to whether variation of susceptibility varies with breed has not been attacked.

Less frequent opportunities of acquiring infection plays a part in the comparative rarity of the disease among Indian animals.

Attention is drawn to the danger to indigenous herds resulting from the possible existence of tuberculosis among imported animals. Further attention is drawn to the fact that the subcutaneous injection of 50 mgms. of culture of tubercle bacilli into Indian cattle does not furnish a criterion as to whether the bacilli injected are of human or bovine origin. The result of such an injection into European or American animals is considered a crucial test of the type of bacilli used.

The experiments throw some light upon the practical absence of lesions due to the bovine type of bacilli in human beings in India.

TAYLOR, G.—NOTE ON THE PREVALENCE OF BOVINE TUBERCULOSIS IN THE PUNJAB. *Indian Journal of Medical Research*, Vol. V, No. 3, January, 1918.

In this paper the author gives details and a tabular statement of his findings in the course of an inquiry extending from August, 1915, to March, 1916.

During this period 3,276 animals were brought to Ferozepore for slaughter. Practically the whole of them came from Central and South-Eastern Punjab, and all were of the indigenous breed. The system of inspection entails examination prior to and subsequent to slaughter, and only those found to be apparently in health and in good condition while alive are allowed to be killed for subsequent inspection.

It is pointed out that 17·8 per cent. of the total number were rejected for various reasons while alive. In view of the fact that the greater number of them were rejected for innutrition—a condition most frequently associated with chronic tuberculosis—it appears to be probable that of the animals rejected prior to slaughter a considerable number were tuberculous.

Attention is further drawn to the fact that carefully selected stock were dealt with, a point which must be borne in mind when the possible prevalence of tuberculosis among cattle in general is being considered.

In all, 95 animals were found to have lesions which, to the naked eye, appeared to be tuberculous. The fact that the whole of the cases were found to occur in females is not evidence of sex incidence, as practically the whole of the beef is derived from cows and heifers. In all cases but two the lesions were confined to the thoracic cavity—the bronchial and mediastinal glands alone or together with the lungs. In one of the exceptional cases there was tuberculosis of the mesenteric glands, and in the other extensive disease including tuberculosis of the udder. Tubercle bacilli were found by microscopic examination in 60 out of 95 cases, but it appears to be probable that this proportion is too low, bacilli having escaped detection in some instances.

During the year 1916-17, 4,610 animals were brought for slaughter, of which 17·8 per cent. were rejected as unfit for slaughter. Of the remaining 3,789, 3·3 per cent. were found to be infected.

These figures would appear to indicate that, at least as far as concerns the Punjab, tuberculosis is not as rare a disease among Indian cattle as has been thought.

It is pointed out that up to the present all the cases of bovine tuberculosis in Indian cattle have been recorded in Northern Provinces. On the other hand, the absence of or the limited nature of inspection in other parts may explain to some extent the absence of records of the disease.

HELMINTHIASIS.

LANE, CLAYTON.—ANCYLOSTOMA DUODENALE AS A PARASITE OF FELIS TIGRIS. *Indian Journal of Medical Research*, Vol. V, No. 1, July, 1917.

The author gives a description of the finding of five specimens (four female and one male) in the jejunum of a tiger, and establishes beyond doubt the fact that the worms found must have been actual parasites of the animal.

Figures are given showing the parts upon which the identification was based, and attention is drawn to the fact that, though the worms were somewhat smaller than those found in man, the question of size alone cannot be held to justify the view that the parasites were not actually specimens of *Ancylostoma duodenale*.

This discovery is held to make no material difference to the measures necessary to prevent the infection of man; but it definitely establishes the fact that man is not the sole host of the worm.

CONTAGIOUS ABORTION.

MCFADYEAN, J., and EDWARDS, J. T.—CONTAGIOUS ABORTION IN MARES AND JOINT-ILL IN FOALS—ETIOLOGY AND SERUM TREATMENT. *Journal Comp. Path. and Therap.*, Vol. XXX, No. 4, December, 1917.

Before detailing the results of their own experiments which were begun in April, 1916, the authors give a valuable review of the research work that has been carried out by other investigators.

At the outset the authors state that the organism which they have isolated is identical with that found by De Jong, Good and

Corbett, and which has been named by the latter *Bacillus abortivo-equinus.*

In view of this fact a detailed description of the bacillus is not given. Photographs shew the appearance of the bacillus under the microscope and the characteristic appearance of the growth on the surface of agar.

It is pointed out that while the immense majority of the organisms are short or ovoid the bacillus is pleomorphic and distinctly longer bacilli are not infrequently found both in infected materials and in artificial cultures.

The most important characteristic feature of the organism for the purpose of identification is the form of growth that develops on agar.

The authors' on description of this may be quoted: "Although previous authors have generally referred to this surface irregularity as a 'wrinkling' the word does not very accurately describe the appearance, as close inspection shews that it depends upon the development of intersecting ridges by which the otherwise flat surface is divided into a series of spaces. These spaces vary in size and shape, but nevertheless form a comparatively regular pattern, which, when the spaces are largest, recalls the appearance in miniature of tanned alligator or lizard skin. Within some of the spaces a very much finer pattern, resembling finger prints, is seen.

"This appearance is not always obtained, especially if the growth be meagre, but it is present when abundant and rapid multiplication of the bacillus occurs."

The authors have isolated this bacillus from ten foals in all. The first two animals were foals born dead a month before full term. The bacillus was recovered in pure culture from the heart blood, liver, stomach, and intestines.

The eight other animals were foals born dead or dead of joint-ill. From all these animals the organism was cultivated from the heart blood, liver, spleen, and other organs, and in the foals born dead from the stomach and intestines also.

In six instances it was cultivated from the liquid in one or several joints and it was noted that three of these foals were born dead and shewed no evidence of joint disease.

Two of the ten animals from which the cultures obtained were not pure at the outset were foals that had died of joint-ill. One of the foals developed joint-ill three weeks after birth and died a few days later. While cultures from the pleural, pericardial, and peritoneal fluids, kidney, a stifle and an elbow joint were pure, those from the heart blood, mesenteric glands, spleen, liver, lungs, and a hock joint shewed also streptococci. A similar contaminating organism was found to be present in small numbers in some of the cultures made from the second case.

The identity of the organism in all cases was settled by cross-agglutination tests.

The authors detail the evidence available upon the question as to whether the bacillus isolated is the cause of abortion and joint-ill, and their conclusion is :—" For these different reasons it appeared to us that it was justifiable to accept the bacillus as an actual cause, and probably the commonest cause both of outbreaks of abortion in mares and of joint-ill in foals.

Having established this fact the authors proceeded to carry out experiments in connection with the production of a protective serum. For this purpose three horses were inoculated intravenously or subcutaneously at intervals during a period of three or four months.

The serum from these horses was tested by agglutination, and it was not issued unless a dilution of at least 1 in 5,000 produced complete agglutination.

The dose was fixed at 50 c.c. for a foal and it was advised that a second dose should be given after a week if improvement was not observed.

The serum was issued free to veterinary surgeons on condition that it was used solely for foals suffering from joint-ill, that no other treatment was resorted to, and that the results were reported.

The total number of doses issued was nearly 500, but reports regarding the results obtained were received in only about 40 per cent. of cases.

The authors give a brief history of each of the 192 cases regarding which reports were received. Of these, 172 were cases in which there was actual disease of the joints and the remainder were cases in which there was suppuration of the navel or pervious urachus but no distinct disease of the joint.

Before summarizing these results the authors draw special attention to certain points. The number of foals treated is too small to warrant any firm conclusion being drawn from the results obtained. The absence of any controls or any certain knowledge of the average fatality of the disease when it is not treated in any way and the possibility that all the cases treated were not etiologically identical are also factors militating against the formation of a definite opinion as to the value of the serum.

It was impossible to obtain any quantity of evidence as to the course joint-ill would take if left untreated and attempts to obtain information as to the average mortality in treated cases failed to yield any from which an average could be calculated. Of the cases shewing evidence of joint-ill 37 per cent. recovered. It is pointed out that before deciding that a death rate of 63 per cent. preves that the serum is valueless certain points must be considered. It must be admitted that in ordinary practice many cases of joint-ill are beyond hope of recovery when the practitioner is called in and that foals which shew evidence of the disease within a few days of birth are born infected, the bacilli being distributed throughout the body.

The figures given by the authors shew that twenty of the foals treated with serum died on the first or second day after the serum was injected. The treatment of such cases was therefore hopeless.

A second point is that experience with anti-sera of all kinds shews that it is of the utmost importance that the serum should be administered as early as possible.

Thirty-nine of the foals had been ill for four days or more before the treatment was started. Further, in a number of cases which ultimately proved fatal there was decided and in some cases striking improvement. As a point indicating that the numbers dealt with are too small to justify firm conclusions as to the value of the serum, it is pointed out that while only seven foals out of twenty-seven treated two days after the onset of illness recovered, seven out of fourteen treated during the second week recovered.

The second group of animals treated comprised twenty-one animals which shewed no lesions of the joint but had either pervious urachus or suppuration of the navel. Of these 42 per cent. recovered. In this connection it is pointed out that the bacillus responsible for joint-ill is probably a very frequent cause of navel suppuration since 87 out of the 172 in the first group shewed suppuration of the navel.

The conclusions arrived at are as follows :—

(1) Our observations indicate that the common cause of abortion in mares and joint-ill in foals in Great Britain is the *Bacillus abortivo-equinus*.

(2) The treatment of cases of joint-ill by means of a serum obtained from horses hyperimmunised against this bacillus has yielded encouraging results.

Selected Articles.

FOOD PRODUCTION : CONSIDERABLE INCREASE POSSIBLE.*

(From a Correspondent.)

ENGLISHMEN used to laugh at Indians for having no subject of conversation except the price of food. The old gibe has now lost its point, for the topic has assumed an absorbing interest throughout the world ; the possibility of universal dearth is now being seriously discussed, statisticians are eagerly scanning the needs and the resources of every country in turn, and it may serve a useful purpose to indicate succinctly the Indian position as it stands to-day, and the extent to which India can assist Europe in case of need.

In India food means grain and pulse, for while meat is eaten and also fish, the supplies of these articles are organized on a local and, so to speak, retail basis, and they have practically no bearing on the position in Europe. As regards the production of grain and pulse, a clear distinction must be drawn between the case of India and that of thinly-populated countries like Canada, which look mainly to the European market. India grows food primarily for her own needs, but in prosperous times she has a surplus for export, which is small in comparison with her total production but is large enough to make a substantial difference to the markets of the West.

The official statistics of the yield of food are not altogether complete, but, taking them as they stand, it may be said that in favourable years India counts on a surplus of something like five

* Reprinted from *The Times* Trade Supplement, February, 1918.

million tons after providing for local consumption of from twelve to fourteen times that quantity. When seasons have been bad this surplus may almost disappear, and in any case a substantial proportion of it is consumed in various parts of Asia and Africa, so that the supplies which reach Europe may range from four million tons down to practically nothing. Indian production is exceedingly varied. Burma rice and Punjab wheat are familiar in Western markets: Indian maize, barley, and the commonest of the pulses (known as gram) have all been sold largely in this country as feeding-stuffs; some of the barley has found favour in the eyes of brewers; and in addition to these there are several pulses and a whole tribe of millets, the names of which are unknown in the West, though the presence of some of them may occasionally be noticed in the samples of feeding-mixtures displayed in English country towns. The surplus which India puts on the market is therefore well worth having, the best of it for human consumption and the rest for turning into meat and milk.

Increased production foreshadowed.

Such is the present position. As regards the future, it is permissible to anticipate a substantial increase in the production of the land. The limits of the indigenous systems of agriculture have, it is true, been nearly reached, but, thanks mainly to the initiative of Lord Curzon, reform is now in the air, and the application of science and of capital to the conduct of the peasant's business is likely to proceed with cumulative effect until India becomes a very much richer country than she is to-day. This change, however, will be gradual, and at first it will be slow. Capitalist farming is practically confined to the production of a few special crops such as tea, and, speaking broadly, the land of India is held in minute sub-division by nearly forty million families of peasants, who decide what crops shall be grown and on what lines their cultivation shall be conducted. The Indian peasant has many qualities in common with the peasants of European countries: steadfast, patient, and laborious, he is also cautious, diffident, and slow to follow the advice which reaches him from outside. The possibilities of co-operative

finance and of the scientific development of farming are steadily winning his recognition, but the process inevitably takes time, and it may be stated with confidence that, while a marked increase in production is now assured, it cannot take place so quickly as to avert a world-scarcity such as some authorities foresee in the near future.

Nor can any large immediate results be expected from the extension of cultivation to the areas of untilled land still to be found in some parts of the Indian Empire. The land is there, and not all of it is barren, but peasants are slow to move into the void, and their efficiency depends largely on specialized knowledge which applies only to the soil and climate of their homes, while many of the waste spaces are uninhabitable without long and expensive preparation, and, above all, are unprovided with water even for domestic purposes. These vacant lands will some day be brought under the plough or otherwise utilized for the benefit of the country, but the process will take time, and again time is of the essence of the problem. A third possibility remains, to grow food on the area usually devoted to industrial crops, and it is in this way alone that India can contribute any sudden large increase to the world's supplies. Official statistics, which, as has been said above, are not altogether complete, show that of late years about forty million acres have been occupied by these crops, rather more than half this figure being cotton, and the bulk of the remainder oilseeds. This land is in no way earmarked for these particular crops. Nearly all of it is fit for growing food, and its allocation already depends largely on the views which the peasants take of the future course of prices ; if, therefore, the mass of the peasants were in a position to realize the imminence of a world-scarcity of food, they would, as a matter of business, curtail sowings of industrial crops and devote themselves to placing the largest possible quantity of foodstuffs on the market. To expect Indian peasants to do this is, however, to ask too much ; the news which reaches them is scanty, delayed, and distorted, while they are not in the mass able to appreciate its true significance, and if they are left to themselves the results are likely to be partial and inadequate.

Government direction necessary.

If, then, there is reason to anticipate a world-scarcity of food—a question which can be decided with authority only by the War Cabinet—and if there are prospects that the food can be carried to the hungry, or even that the hungry can be carried to the food, the mobilization of India's agricultural resources must be directed by the Governments of the country, and not left to individual enterprise. Some tentative measures in this direction have already been taken, but their effect is likely to be local, and if the need is found to be real and urgent, more general and drastic action will be required; the area of the industrial crops must be curtailed and ten, twenty, or even thirty million acres diverted to the production of food. On the average about three acres will yield a ton, so that, given favourable seasons, the surplus of food which India sends to Europe could for a single year be doubled or even trebled at the cost of curtailing the supply of important raw materials and of forcing Asia to wear old clothes in order that Europe may not starve.

Such an undertaking would be of enormous magnitude, and every one must hope that the necessity for it will not arise, but it is quite within the competence of the existing land administration, which works so quietly that Englishmen are apt to forget that, though not perfect, it is probably the most efficient piece of human machinery in the world. The one thing essential is that the orders should be issued in time. Once the annual rains have started, the peasant must work; his time for thinking and planning is then over, and interference from above might do almost as much harm as good. If, however, plain orders are issued in the spring and measures are taken to ensure an adequate supply of seed and capital, the result would be seen in increased supplies of maize, millets, and pulses coming forward in the following autumn, and of wheat, gram, and barley a few months later, in time to reach Europe at the critical period when it is waiting for the northern harvests to begin.

A word of warning must be offered by way of conclusion. If the War Cabinet should unhappily be driven to the decision that India's peasants must be mobilized in the interests of the world's

food, the operation must be so conducted as to afford no scope for a cry of exploitation. The peasant will be asked to sacrifice his independence ; that sacrifice ought to suffice, and he should not be required to undertake increased financial liability. In other words, the curtailment of industrial crops must be accompanied by a guarantee of minimum prices for food grains sufficient to ensure that the peasant shall not be a loser, and that politicians or agitators shall be given no grounds for a charge that India is paying dearly to provide Europe's food. Given this condition, it is not unreasonable that the area which is already a reserve against scarcity of food in India should be claimed in the interests of that civilization in whose benefits India shares.

VEGETABLE FIBRES.*

FROM the following table of values of the exports from India of vegetable fibres and manufactures thereof for the last two years, it will be seen that jute is commercially by far the most important of Indian fibres.

Exports from India.

	1915-16	1916-17
	£	£
Raw jute	10,428,024	10,858,736
Jute manufactures	25,318,934	27,769,725
Total ..	35,746,958	38,628,461
Raw cotton	16,619,247	22,787,591
Cotton manufactures .	6,403,973	8,506,423
Total .	23,023,220	31,294,014
Raw hemp, chiefly sunn hemp ..	683,538	1,015,476
Kapok	27,513	26,911

India is the only country where jute is produced on any scale, and the total area under this crop in 1916 (2,702,700 acres) was 14 per cent. above that in the preceding year, whilst the yield (8,305,600 bales of 400lb. each) rose by 13 per cent. The area and yield for 1917 are estimated at 2,729,700 acres and 8,839,900 bales respectively.

Since March 1, 1916, export duties on jute, other than Bimlipatam jute (see below), have been levied in India. On raw jute the tariff is 1¼ rupees per bale of 400lb. for "cuttings," and 4½ rupees for all other descriptions; on jute sacking (cloth, bags, twist, yarn, rope, and twine) 20 rupees per ton; and on hessians and all other desrciptions of jute manufactures not otherwise specified, 32 rupees

* Reprinted from *The Times* Trade Supplement, February, 1918.

per ton. No export duty is charged on jute manufactures in actual use as coverings, receptacles, or bindings for other goods.

Extension of jute production.

The question of the possibility of a large expansion of jute production in India is of great importance. There are three possible ways of increasing the output: (1) By improving the yield per acre by better methods of cultivation; (2) by extending the area under cultivation; (3) by the cultivation, in tracts which are not suitable for the production of jute, of other plants whose fibre is sufficiently similar to be used as a substitute. Mr. R. S. Finlow, Fibre Expert to the Government of Bengal, has stated that agricultural improvement is destined to be of great importance in connexion with jute. Already the Agricultural Department has produced by selection improved races of plants with a yield and quality of fibre better than the average, and seed farms are being established to produce seed of these plants on a large scale for distribution to cultivators.

Other work of the Agricultural Department points to enhanced yields by means of improved methods of cultivation and manuring. It is clear that agricultural improvement alone contains the prospects of a largely increased total output of jute, but although the ultimate effect may be great, progress at first seems slow, owing to the intense conservatism of the cultivators and their great number. As regards extension of cultivation, jute has been grown experimentally with success in many parts of India, and big crops have been produced in the irrigated tracts of the Punjab, the Central Provinces, and Madras. But in all these provinces conditions are much less favourable than in Bengal, and the opinion of those qualified to judge is that jute cultivation is hardly likely to be taken up on a large scale outside Bengal, Bihar, and Assam. The natural direction in which jute cultivation could extend is into the plains of Assam, where soil and climate are peculiarly suited to the crop—an addition of fully a million acres to the area would be possible there. But lack of population is an almost insuperable bar to any rapid extension, and by nothing short of a wholesale colonization scheme can progress be other than slow.

Jute substitutes.

In these circumstances, great interest attaches to the question of jute substitutes, of which Bimlipatam jute or Deccan hemp (*Hibiscus cannabinus*) yields a fibre similar in many respects to jute, whilst certain varieties afford a stronger and possibly more durable fibre. For this reason its cultivation, which is at present carried on in Madras, as well as in Bombay, Bihar, and the United Provinces, is worthy of encouragement. In fact, any prolonged shortage in the supply of true jute is fairly certain to cause a development in the cultivation of Bimlipatam jute. The Agricultural Department has studied the different races of this plant, and has selected for multiplication the seed of those producing the best fibre, so that pure seed of the best kinds can be supplied in large quantities to cultivators.

COTTON.

The area under cotton cultivation in India increased, under the stimulus of high prices, from 17,746,000 acres in the year 1915-16 to 21,212,000 acres in 1916-17. The yield was 4,273,000 bales of 400lb., which is 14 per cent. larger than that of 1915-16. Rather more than half the cotton produced in India is used in the cotton mills of the country, which are 233 in number, with 6,209,377 spindles, 96,869 looms, and 240,719 employed persons.

Japan, the chief purchaser of India's exports of raw cotton, took 68 per cent. of the total exports in 1916-17. The following table shows the chief destinations of the exports of raw cotton from India last year and in the year before the war for comparison :—

To	1913-14	1916-17
	Tons	Tons
United Kingdom	19,245	40,056
Germany	84,403	......
Belgium	56,654	... ..
France	26,213	13,247
Spain	8,346	12,698
Italy	42,429	48,319
Austria-Hungary	37,352	... ...
Japan	240,878	289,542
Other countries	15,795	21,380
Total ..	531,315	425,242

Of late years, owing to the efforts of the Indian agricultural officers, Indian cottons have improved in quality, and there is every reason to hope for further progress in this direction. Attempts have been made from the earliest days to introduce foreign varieties of cotton but with little success, and effort is now directed chiefly to the improvement of the indigenous cottons. The procedure is to isolate and maintain pure types, to improve quality by selection, and introduce the improved plant into general cultivation. By this means, varieties with higher yields and larger lint percentage have been obtained in Bombay and Madras, in the Central Provinces and in the United Provinces. At the same time, attempts have been made to introduce exotic varieties, especially into districts where they had not been cultivated before ; thus Egyptian and Upland American cottons have been introduced into Sind ; American varieties have been established in Bombay, the Punjab, and the United Provinces, and one type of "Upland Georgian" in the Central Provinces ; but the best achievement of the agricultural experts has been the introduction of "Cambodia" into Madras.

Though Lancashire is only a small consumer of Indian cotton, home interests are linked with the extension of cotton cultivation in India, because, with the present shortage, every additional bale of Indian cotton produced sets free a bale of American cotton.

Sunn Hemp.

The cultivation of sunn hemp (*Crotalaria juncea*) in India is reported to be increasing, and the demand at present in the United Kingdom is great. The exports in 1916-17 were 35,060 tons. This variety of hemp from Bombay and other parts of India is being taken by rope manufacturers in the United Kingdom in substitution for Russian hemp which is so scarce. Some grades of sunn hemp from India arrive here full of dust, and manufacturers have complained to their factory inspectors, with the result that the Home Office suggested recently that the Government of India should legislate for the grading of Indian hemps before exportation. The conclusion arrived at in India, however, is that legislation is altogether impracticable, and that the remedy is for buyers in the

United Kingdom to reject parcels containing an unduly large percentage of dust. To encourage the exportation of dressed hemp, buyers should be prepared to pay a higher price for the marks upon which they can rely, and they should avoid their present tendency to buy cheap substitutes for marks of established grades.

Though **flax** is not indigenous to India, it is appropriate to mention here that the possibilities of flax cultivation there have from time to time received the attention of planters, and some years ago complete experiments in the growing of the crop and its preparation for market were made by a Belgian expert, Mr. Vandekerkhove, engaged for the purpose by the Bihar Planters' Association. The results showed that flax can be successfully grown and prepared in Bihar at a profit of £4 to £4 4*s*. per acre. At that time, however, there was no general inclination to take up the cultivation and manufacture as prices were uncertain; but it has been demonstrated that the crop can be grown in Bihar at a fair profit and a possible investment for capital has thus been indicated.

Kapok floss.

The exports of kapok floss from India have decreased from 16,023 cwt. in 1914-15 to 13,312 cwt. in 1916-17. Kapok has long been used as astuffing material in upholstery, and during the last three years it has found a large demand as a packing material for life-belts and life-saving waistcoats, for which purpose its buoyancy and impermeability to water render it extremely suitable. The best kind of kapok is derived from the tree *Eriodendron anfractuosum* and comes from Java. Though this tree occurs in India and its floss is sometimes collected, most of the kapok shipped from India is derived from other trees and is usually inferior in resiliency and non-absorbent quality, as well as less carefully cleaned and prepared than the Java product. Hence its market value is lower. It is believed that if more careful methods of collection, cleaning, and packing were adopted for the Indian product it would find a better demand at a higher price.

NITROGEN FIXATION.*

IN connection with the efforts that are being made in the United States to secure an adequate supply of nitric acid and nitrates, Dr. C. L. Parsons, as a result of enquiries and visits to plants in Italy, France, England, Norway, and Sweden, has prepared a report on the different processes in use. His conclusions are based on an estimate of the United States Government's maximum requirements of nitric acid for munitions purposes, *viz.*, 20,000 tons in peace time and 180,000 tons in time of war. Dr. Parsons says: With these quantities as a maximum, and a sufficient supply of sodium nitrate in storage to meet the requirements of the Government for a period of six months to one year, no serious emergency problem confronts the Government. The increase in the output of ammonia from by-product coking since 1915, if oxidized to nitric acid, is alone more than sufficient to meet this requirement. The oxidation of ammonia, including that produced from the destructive distillation of coal, presents no serious difficulties, and the necessary plants using the emergency procedure adopted in Germany could in case of need be quickly installed to meet the Government requirements. Such installation would involve much cruder procedure, such as lower efficiency of oxidation and absorption of the nitrous oxides in soda lye, than would be adopted after careful experimentation and experience in the operation of the most efficient plants, but it would nevertheless furnish the country with the nitric acid required.

In my opinion, the following methods include the only ones which need to be considered in the final choice of the procedure to be employed by the Government in providing a source of nitrate supply.

---

* Reprinted from the *Journal of the Society of Chemical Industry*, vol. XXXVI, no. 20, October 31, 1917.

Arc Process.

The arc precess is now installed in Southern Norway, employing 250,000 kilowatts of electricity developed from the cheapest large installation of hydro-electric power in the world. This is the only large installation of the arc process, but small installations of an experimental nature have been made in other countries. The method is one of the most inefficient known as regards production in relation to power consumed. Nevertheless, on account of the very cheap horse-power available in Norway, nitric acid can there be produced by the arc process at a cost less than by any other commercial process. Incidental to the production of nitric acid, a large excess of heat is developed, which can be, and is in part, converted into steam which may be, and is, used for concentrating the weak nitric acid obtained in the absorption towers to the strong acid required for munitions works. The excess of steam is so large that many other methods for its application have also been devised. As the labour costs also are low, when once under way, the operation goes on almost automatically. As the formation of nitric acid is direct and involves only the nitrogen and oxygen of the air and water as raw materials, no complicated processes involving intermediate products are necessary, as is more or less the case with all other processes.

In spite of these manifest advantages, however, it appears to be the general opinion of the European engineers with whom I came in contact that, even with the cheap horse-power enjoyed by the Norwegian plants, they might have had to discontinue their operations except for the stimulus given by the present European war. Even as it is, the Norsk Hydro Company, operating the arc plants at Notodden and Rjukan, have been obliged to install large ammonia-producing plants in order that they might convert their nitric acid to ammonium nitrate and thus render it transportable to markets where it was needed.

The cost of horse-power used for the production of nitric acid in Norway is less than \$5 per horse-power year. With horse-power at \$10 per horse-power year, the cost of finished strong nitric acid at the plant should be as cheap as by any other process now in operation.

However, the low cost of producing nitric acid by the arc process is outweighed by so many other disadvantages that, in my opinion, the process is entirely inapplicable to the use of the United States Government, and this opinion appears to be shared by all who have given careful thought to the subject. The cost of installing the arc process is high, and it involves the use of an amount of horse-power that seemingly is not available on the American continent within reach of the points where the nitric acid would have to be used.

The great difficulty that has faced the Norwegian plants from the beginning, namely, a market for their products, would in peace times be a serious obstacle to the operation of a large arc plant in the United States. An arc plant at its best involves the use of 2·33 horse-power years per ton of weak nitric acid. This means that a water-power development of at least 50,000 horse-power would be necessary for the peace requirements of the Government, and a development of 440,000 horse-power would be required for war purposes. These figures are minimum figures, on the basis of the relatively high efficiency reached in Norway. No installation should be considered by the Government of less than 75,000 horse-power for peace requirements or 550,000 horse-power for war requirements. If the arc process is to be used it would also be advisable to arrange for the production of explosives at the point where the arc plant was located. This would, of course, involve the transportation of all other raw materials needed to the plant and transportation of the finished explosives therefrom to the place of consumption. As these materials are highly combustible and for the most part carry high freight rates, it has been found necessary the world over to locate the plants intended for the production of munitions near to the point where the munitions are likely to be consumed.

An arc plant of sufficient size to meet the requirements of the Government in time of war would probably have to remain idle for the main part during times of peace, owing to the difficulty of disposing of the nitric acid that the plant would produce if in operation. On account of the large amount of horse-power required, and the consequent extent of the necessary plant and tower absorption

capacity, the cost of installing an arc plant to meet the war-time requirements of the Government would be several times the total appropriation made for the purpose by Congress.

Haber Process.

The Haber process has grown very rapidly in the last three years. It was first commercially installed in Germany in 1913 with a plant capacity of 30,000 tons of ammonium sulphate. Seemingly, it actually produced in that year some 20,000 tons of ammonium sulphate. This grew to 60,000 tons in 1914; 150,000 tons in 1915; and 300,000 tons in 1916; and it is authoritatively stated that with new works now under construction by the Badische Company, the 1917 output of ammonia by the Haber process would be equivalent to over 500,000 tons of ammonium sulphate.

The production and purification of hydrogen made either by the reducing action of coal or iron upon steam involve one of the chief items of cost in the Haber process. The fact that the combination of nitrogen and hydrogen takes place at temperatures above 500° C., and at pressures of 125 to 150 atmospheres, involves some danger and many other technical difficulties which have, however, seemingly been overcome in Germany. The technical control of the Haber process is of such great importance and requires so high a degree of training and skill that it is reported if the Badische people were to lose their present technical staff of experts familiar with the process, many months would be required to train another staff capable of applying the process in practice.

The Haber process is not at present in use outside of Germany on account of the lack of detailed information regarding plant construction and operation, and also owing to the very large royalty demanded by the Badische Company for its use by other concerns. It is, however, more than probable that the Badische Company will itself install and develop the process outside Germany when the war is ended.

Trustworthy information regarding the costs of production of ammonia by the Haber process indicates that pure anhydrous ammonia can be produced in liquid condition at a cost slightly less

than 4 cents per pound. It is improbable that any arrangement could be made for the United States Government to use the Haber process pending the conclusion of the European war. It is probable that, when the war is ended, the Haber process will be installed, or will be available for installation, in the United States. It is the cheapest process for the production of synthetic ammonia. It is independent of cheap power—the power being a small fraction of its cost. If desirable, it could be readily installed in moderate-sized units in connection with ammonia oxidizing plants at any munitions plant.

Cyanamide Process.

The cyanamide process has been developed in many parts of Europe, but in the Western Hemisphere only at Niagara Falls, Ontario, Canada. It requires cheap power for its successful operation, and has obtained its greatest development owing to the fact that it requires only about one-fifth the horse-power per ton of fixed nitrogen per year that is required by the arc process.

Ammonia from cyanamide, with power at $8 per horse-power year in a plant to be constructed by the Government, would cost 1 to 2 cents per pound more than by the Haber process. On the other hand, royalties for using the cyanamide process would undoubtedly be less. The technical problems involved are understood by many engineers both in this country and abroad, the manufacture of calcium carbide and cyanamide being established in many plants, and the basic patents having only some four years more to run. Peculiarly favourable conditions exist for its installation in certain sections of the South. If a hydro-electric plant is to be installed by the United States Government, and the electrical power so developed be used for the fixation of nitrogen, the cyanamide process has advantages over all other processes now developed, and should be adopted as the best means of utilizing hydro-electric power for the fixation of nitrogen.

In Germany, in 1913, there were produced 30,000 tons of cyanamide. The growth has not been so rapid as in the case of the Haber process, although the process has been subsidised by

the German Government to assist in its development. However, the 1917 German production will be not far from 400,000 tons. The cyanamide interests in Germany have also endeavoured to induce the German Government to establish a nitrogen monopoly which will insure the continuation of the cyanamide industry in Germany in competition with the Haber process and ammonium sulphate from coke ovens after the war. Cyanamide has not found favour with American fertilizer manufacturers, and is not well suited as an addition to the mixed fertilizer demanded by American farmers. It is, however, successfully used in Europe where labour is much cheaper. To meet the Government's requirements of 20,000 tons and 180,000 tons of nitric acid through the medium of cyanamide would require the continuous use of 11,000 horse-power and 99,000 horse-power respectively.

If cyanamide is to be converted into the most popular form of fertilizer material, namely, ammonium sulphate, it would cost approximately 1 cent per pound to convert the nitrogen present into the form of ammonia before it could be absorbed to form sulphate. It is the necessity of converting the combined nitrogen into ammonia, if the cyanamide process is used as a source of nitric acid, that makes up a considerable portion of the difference in cost between cyanamide ammonia and Haber ammonia.

By-Product Ammonia.

In the United States less than one-tenth of the bituminous coal burned is coked in by-product ovens. Of the coke produced in America, over one-half is still produced in beehive ovens in which the gas, ammonia, and all other by-products are ruthlessly destroyed. There has been nevertheless a rapid increase in the installation and operation of by-product ovens, and an increase in ammonia production that would not have been thought possible two years ago. By the end of the present year we will be producing at least 115,000 tons of ammonia per annum—an equivalent of 450,000 tons of ammonium sulphate. Six thousand tons of this ammonia in time of peace, or 55,000 tons in time of war, would meet the nation's requirements of nitric acid for military purposes, as estimated by

the War Department. The growth of our ammonia production from by-product coking has been extremely rapid, and is still on the increase. More than fifty million dollars' worth of by-product coke ovens have been contracted for within the past twelve or thirteen months, and are now completed or in process of erection.

The general use of coke instead of coal throughout the United States would produce, besides other by-products, approximately 1,000,000 tons of ammonia. The day is far off before this highly desirable result will be reached, but it should none the less be striven for. Already legislation abroad requires the use of coke instead of bituminous coal for certain industrial purposes. By-product coke ovens, however, cannot be installed by the United States Government for the purpose of producing ammonia. The ammonia should be simply a by-product incidental to the production of coke for industrial purposes. Under war conditions, however, the output of ammonia from by-product coke ovens could, by Government regulation, be greatly increased. This has been accomplished in Germany, the by-product coke ovens furnishing Germany to-day with over one-third of the nitrogen consumed in that country. Germany has had an increase from 100,000 tons to 154,000 tons of nitrogen from this source since the war began. The possibilities for an increase in America are much greater than in Germany.

Ammonia from by-product ovens has to be purified before it can be oxidized to nitric acid. The cost of purification is, however, very small, and, where purification apparatus is installed at the original ammonia absorption plant, adds but a small fraction of a cent a pound to the cost of crude ammonia liquor.

The use of by-product ammonia for the production of nitric acid for munitions purposes has the great advantage that it is already available, and that the plants, being situated in numerous parts of the country, could furnish ammonia to several small oxidizing plants. Accordingly, the country's source of munitions supply would not be at any one place and subject to capture and destruction.

The use of by-product ammonia has the great disadvantage that the present selling price of ammonia from by-product coke

is high, and unless considerable price concessions could be obtained by the Government, it could not afford to utilize this source of raw material for nitric acid. The actual cost of pure ammonia considered as a by-product from the coking of bituminous coal is much less than by any other method now producing this substance.

Cyanide Process.

The cyanide process is not yet a commercial success, but it has great possibilities. There is no difficulty whatever in the chemical reactions. No power factor of any consequence is involved, and it appears certain that if the mechanical difficulties are solved, nitrogen will be fixed in this form cheaper than by any other known synthetic process. There are also large quantities of waste nitrogen available in connection with the sodium carbonate plants of the country, where the sodium carbonate required would also be available, and there are large amounts of nitrogen that could be obtained without cost in a sufficiently pure condition at the wood-pulp plants using the sulphite process.

When the sodium cyanide is once formed, it can be readily converted into ammonia, as is the case with cyanamide; but the process has the advantage that in the conversion the sodium carbonate can be recovered to be used over again. The iron can also be repeatedly used in the process. Small installations are now working successfully in the country, but the mechanical difficulties of production on a large scale are yet to be solved. Four large American corporations are engaged on the problem with ample funds for its solution.

The process has the further advantage that it would also make cheaply available cyanide which is so greatly needed by our mining industries.

Nitric Acid from Ammonia.

All processes for the synthetic production of nitric acid, except the arc process, involve the oxidation of ammonia. The processes commercially in use involve the direct oxidation of ammonia gas in the presence of air in contact with metallic platinum. In Germany,

according to the latest published figures, approximately 100,000 tons of nitric acid are annually produced through the Frank-Caro process which involves passing mixtures of ammonia and air through electrically heated platinum nets of 80 to 100 mesh. The platinum is heated to a dull red heat, and serves as a catalytic agent under whose influence the ammonia, instead of burning to nitrogen and water as normally would be the case, is oxidized to nitric oxide.

In the Kaiser process, also used in Germany, the air is heated before its mixture with the ammonia, and under these conditions it is claimed that no electric heating of the platinum net is necessary. The Kaiser process does not appear to have reached any large commercial development.

In the Landis process, installed in a small experimental plant at Warners, N. J., the gas is passed downwards through the net instead of upwards as is customary in the Frank-Caro process, and according to the Landis patents, the gases are cooled before they are allowed to come in contact with the net instead of being heated as in the Kaiser process. The platinum-net process is also understood to be installed in a small plant in Long Island City, and is being installed in Syracuse, N. Y., by the Semet-Solvay Company in co-operation with the Bureau of Mines.

The Ostwald-Barton process, first developed at Villevorde, Belgium, and brought there to a commercial success at the time of the opening of the war, is now installed in two large plants—one at Angouleme, France, and the other at Dagenham, England. The principle of the process is essentially that originally patented by Ostwald, but the catalyser is distinctly different from that used by him, although it consists of metallic platinum. The details of the preparation of this catalyser are kept secret, but it is known to have a very small cross-section and is placed at the end of a 60-mm. tube, so that the products of combustion passing through the tube heat the mixed ammonia and air by radiation as they approach the catalyser. By this means no external heat is necessary. The reaction when once started continues without interruption for weeks. It is simply necessary, by means of blowers, to force the mixture of ammonia and air through

the catalyser. The present commercial efficiency and output by the Ostwald-Barton process is higher than by any other concerning which exact figures have been obtained. It is higher than the published figures for the Frank-Caro process, but as figures for that process have been published only on a minimum basis, it is impossible to state whether as high an efficiency of conversion and capacity of catalyser has been reached by that process as by the Ostwald-Barton.

The processes for the oxidation of ammonia are seemingly free from any complicated patent situation. The Europeans engaged in ammonia oxidation admit freely that they have no important patent rights to sell, but they claim that they have plans, specifications, and details of processes, the purchase of which would be cheaper than the necessary experimentation to work out the details.

By the oxidation of ammonia, nitric oxide gases are obtained of much higher concentration than those produced by the arc process. Accordingly much less tower space is necessary for their absorption, and much stronger acid can be directly obtained by concentration. Although in the arc process the concentration of 30 to 35 per cent. nitric acid to strong acid is required, in the oxidation process an acid of 50 to 55 per cent. strength is easily obtained directly from the towers, and the concentration thereof is accordingly a simpler matter.

A method has been developed in Sweden, details of which are unknown, for the oxidation of ammonia or cyanamide direct to ammonium nitrate in solution. Plants have been erected near Gothenburg, Sweden, and near Berlin, Germany. It is claimed that this process will produce ammonium nitrate much cheaper than any other.

THE NITROGEN SITUATION.

In view of the fact that Germany has invested millions of dollars in synthetic nitrogen plants which will continue to produce nitrogen compounds after the war; that Germany is producing more than twice the amount of combined nitrogen that she formerly imported in the form of Chilian saltpetre; that accordingly the

German market for Chilian saltpetre will be essentially non-existent after the war; that the present large American and Allied consumption for munitions will cease; and that during the war the American production of ammonia from by-product coke ovens has increased to a point in excess of our apparent normal consumption. it seems certain that the price of combined nitrogen for industrial and agricultural purposes must greatly decrease when the war is over.

It is evident at once that the peace-time requirements of the Government for nitric acid could be supplied from coal-tar ammonia with little effect on the market for the material and practically no effect on the country's nitrogen resources. It seems equally certain that in the case of war by-product ammonia could furnish 180,000 tons of nitric acid per year for at least one or two years without seriously affecting the nation's agriculture.

This is particularly important when it is remembered that over 60 per cent. of the nitrogenous material used in fertilizer, consisting of organic nitrogen from cotton seed meal, tankage, dried blood, etc., would not be decreased at all but would rather be increased through the cutting off of exports of cotton seed meal.

Furthermore, it is well known that several of our largest corporations are engaged in active plans for installing synthetic nitrogen plants of various kinds to meet their own industrial requirements, and that in all probability the Haber process will enter into active industrial competition for our ammonia markets in American plants as soon as the war is over. Plants for the oxidation of ammonia can be quickly erected in crude form, as they were erected and utilized in Germany, should the need arise.

I accordingly feel that no serious emergency problem confronts the United States that could not be met with reasonable celerity in time of war, and that our first problem, after securing a reasonable reserve of Chilian saltpetre, is to familiarize ourselves with the most efficient method for the oxidation of ammonia and to train the necessary men to construct and operate ammonia oxidation plants.

Cost of Nitric Acid.

The cost of nitric acid, *per se*, whether as weak nitric acid or as concentrated nitric acid, is lowest by the arc process with hydro-electric power delivered to the furnace at a cost of $10 per horse-power year, or less. The difficulties of its transportation, the large amount of power required, and other economic reasons, as already explained, make the arc process inapplicable to American conditions.

The cost of nitric acid obtained by the oxidation of pure ammonia is independent of the source of the ammonia, and must therefore depend upon the cost of ammonia gas in the gasholders ready to be passed to the oxidizing apparatus.

Cost of Ammonia.

The cost of ammonia has at the present time no relation to its selling price. The actual cost of collecting, absorbing, and purifying ammonia from the gases developed by the destructive distillation of bituminous coal, in other words, the cost of ammonia considered as a by-product, is less than by any other process. The selling price of by-product ammonia is entirely a question of competition with other nitrogenous products, and has been fixed in the past almost wholly by the market price of sodium nitrate with which it enters into competition. Even should ammonia be placed on the market by the Haber process at a price as low as 4 cents per pound, by-product ammonia will still be sold in competition therewith at a profit to the producer. The Haber process can produce, and is producing, ammonia synthetically cheaper than any other synthetic process now industrially applied. The cyanamide process stands next in order.

If mechanical difficulties now confronting the cyanide process are solved, it will produce ammonia cheaper than either the Haber or the cyanamide process, and in close competition with the actual costs of saving by-product ammonia. The details of costs by all of the above methods will be considered in the final report.

SUMMARY OF CONCLUSIONS.

(I) The Government should obtain its nitric acid by the oxidation of ammonia. It should begin the erection of an ammonia-oxidation plant of moderate capacity at an early date in order to train men and obtain experience in the most efficient method of procedure.

(II) The Government should proceed slowly in the matter of the erection of plants for the production of ammonia, as developments in the cyanide process and the availability of the Haber process may render valueless within a short time any large expenditure for the production of cyanamide. This is doubly true in view of the fact that present appropriations are not nearly sufficient to install water power and erect the nitrogen fixation plants necessary to meet the Government requirements as estimated by the Ordnance Department. The adoption of the above procedure involves: -

1. Purchase by the Government of a reserve supply of sodium nitrate of at least 200,000 tons.

2. The purchase of ammonia on the open market.

3. The reservation of a supply of platinum.

4. The construction of a hydro-electric plant only if the arc or cyanamide process is to be used. The oxidation of ammonia requires very little power, and the Haber, cyanide, and by-product ammonia processes are all independent of cheap power cost. The development of water power, however, cannot but be of benefit to the country even if it is not used for the fixation of nitrogen.

I seriously doubt whether hydro-electric power will be necessary or desirable three years from now for the most efficient process of fixing nitrogen, and accordingly I deem it unwise to install such hydro-electric power, at great cost, with the sole purpose of fixing nitrogen. If, however, such water power can be utilized by the Government in the production of certain ferro alloys absolutely essential for ordnance and other munitions; can be sold to commercial companies who will take upon themselves the financial risk involved in the erection of plants for nitrogen fixation, under guarantee of cheap ammonia to the Government; or can be sold

during peace times to companies requiring power for purposes which would allow instant requisition of the power by the Government in time of war without handicapping the supplies of other needed war material, the development of such hydro-electric power would be highly desirable.

The first and third recommendations have already been adopted, and are progressing towards fulfilment.

In a supplementary report, dated April 30th last, Dr. Parsons states that a small plant for the oxidation of ammonia erected at Syracuse, N. Y., is progressing successfully; another experimental oxidation plant at Laurel Hill, L. I., has developed other new features. At Syracuse two new forms of apparatus for the oxidation of ammonia are now being tried, one of which, if successful, will do away entirely with the use of platinum in the production of nitric acid.

Development has been rapid during the last two months. A synthetic ammonia process and a cyanide process have now reached a state of development where I am prepared to recommend definite action by the Government.

General Chemical Company Process.

During the past four years the General Chemical Company, working on the basis that it should be possible to develop conditions under which the synthetic production of ammonia by the direct combination of nitrogen and hydrogen should take place at lower pressures than those deemed necessary by the Haber patents, has achieved success. This process has been in successful operation on a large experimental scale with several small units for ammonia production, and one unit larger than those supposed to be used in Germany. The General Chemical Company has also developed and brought to a commercial basis the production of a mixture of nitrogen and hydrogen from coke, air, and water which will yield hydrogen at a cost lower than heretofore obtained in this country, and probably lower than that obtained in Germany. Complete engineering plans have been prepared and bids obtained on the main items of construction, so that the erection of a plant for the

synthetic production of ammonia can be proceeded with without delay. The Company itself would have already had a plant in operation save for the present high construction costs and other difficulties incident to operations at the present time.

The General Chemical Company has offered the free use of its process to the Government, and the full help of the Company in installing and operating the process.

It is estimated—I believe conservatively—that even under present conditions a 30-ton-per-day plant can be built for an expenditure of $3,000,000, and can be operated at a cost of not to exceed 4 cents per pound of ammonia produced, allowing $5·00 per ton of product for repairs, and 12½ per cent. of the cost of the plant for interest and depreciation. It is believed that the charges for repairs, interest, and depreciation are excessive, as together they comprise more than 50 per cent. of the total cost of the ammonia production. In the estimates $3·00 per ton of product is allowed for general expenses and overhead charges.

It is estimated that a smaller plant of at least 7½ tons per day capacity can be built at the present time for approximately $1,100,000, including land and building. Such a plant would yield 2,700 tons of ammonia per year—equivalent to 8,700 tons of 96 per cent. nitric acid, assuming 85 per cent. recovery. Such a plant would require about 500 horse-power.

I recommend that an initial plant to produce 60,000 lb. of ammonia per day be immediately constructed, and to this end I recommend that the War Department set aside the sum of $3,500,000, and that the initial plant be constructed at some point to be selected by the War Department in South-West Virginia, or adjoining territory in West Virginia, reasonably near to the sulphur, sulphuric acid, and coal supplies of that region, and so situated near to plenty of good water that an ammonia oxidation plant and a powder plant may later be erected near by.

Cyanide Process.

The cyanide process, too, has greatly developed in the last few months.

The President of the Nitrogen Products Company considers the process a certain commercial success, and a probable competitor with any other process for the production of fixed nitrogen. The Company is operating two experimental plants by the cyanide process—one at Saltville, Va., in a coal-fired furnace, and one at Niagara Falls in an electric furnace.

After careful examination of this process, I am not convinced that it has yet reached a point when plant installation should begin, as I believe a few months' experimentation will add greatly to the efficiency of the furnace proposed. It is my belief, however, that the process will become an important factor in the world's nitrogen market; that it may become a strong competitor even of other processes on account of the simplicity of its operations and the low cost of plant construction; and that a furnace, which I believe I see in embryo, can be developed which will be much more efficient than either of those now used.

The process is so promising that I recommend that active experimentation on a large scale be conducted, that a sum not to exceed $200,000 be set aside for this purpose. With this amount available, I feel confident that this process can be put upon a commercial basis; that it will become a real competitor in the production of ammonia for nitric acid and of nitrogenous material for fertilizer.

Estimates of Construction and Operating Costs.

In order that the recommendations made above may be considered in comparison with the older processes now operating on a large scale, I submit herewith a table summarizing confidential data obtained from books of many companies bearing upon the cost of nitrogen production.

Data per ton of nitrogen—by the Arc, Cyanamide, Haber, and General Chemical Company Processes.

	Arc	Cyanamide	Haber	Gen. Chem.*
Product	35% HNO_3	NH_3	NH_3	NH_3
Power required ...	10·5	2·2	0·2	0·2
Investment	\$1410(*a*)	\$440(*a*)	\$340	\$300
Operating costs†	170	150(*b*)	119	97
Product .	96% HNO_3	96% HNO_3	96% HNO_3	96% HNO_3
Power	10·8	2·3	0·3	0·3
Investment‡	\$1550	\$670	\$570	\$530
Operating costs§ .	220	270	239	217

* Estimates on General Chemical Co. process are based on present war-time construction costs. All others on normal prices.

† Amortisation for cyanamide as charged by operating companies. Amortisation for Haber, 20% of plant cost for repairs, interest, depreciation. Amortisation for Arc and Modified Haber, 12½% interest and depreciation. \$5·00 per ton of product for repairs.

‡ Except for Arc process, includes ammonia plant as given; power additional \$10; oxidation, and absorption, \$140; concentration \$40; steam plant \$40.

§ Except for Arc process, includes ammonia costs as given; oxidation \$50; concentration \$70. No allowance made for unoxidized ammonia.

(*a*) Power plant investment reckoned at \$100 per horse-power.

(*b*) Cyanamide production \$122, ammonia from cyanamide \$28, total \$150.

A TEXTILE SUBSTITUTE: EXPERIMENT WITH NETTLE FIBRE. *

STINGING nettle fibre as raw material for the textile industry is in use in a varying degree in Germany, Austria, Denmark, and Switzerland. Originally intended as a substitute, its use has been pressed forward in the Central Empires through the shortage of cotton caused by the war.

THE GERMAN CLAIMS.

The danger of ignoring a substitute is the possibility that by scientific experiments and research it may become a serious competitor with staple industries, before the full extent of the risk has been appreciated. Believing this to be the case with the stinging nettle, and hoping to seize an opportunity of making Germany independent of supplies of foreign cotton, the Germans have studied, tested, and adopted it as a war necessity; there is evidence available showing that they also claim to have discovered a new process for its utilization, which opens up a great future for the industry even after the war. Large quantities of nettles were collected in the summer of 1916 (according to one authority) under the supervision of the 'Nesselfaserverwertungsgesellschaft,' the new German War Company, holding an exclusive right to purchase, if necessary by compulsion, all stems of stinging nettles (*Urtica Diocia*), whether native or imported. This company claimed that a tissue, comparing favourably with that manufactured from American cotton, was obtained from the fibre. Mixed with wool, a cloth of soft texture, hardly distinguishable from expensive woollen material, much cheaper and easily dyed, is said to be produceable, the cloth being suitable

* Reprinted from the *Board of Trade Journal and Commercial Gazette*, London, dated 3rd January, 1918.

for use in the manufacture of furniture covers, plush and suitings. There is, however, no confirmation of this claim, although there is no doubt that the fibre has been used to make linings for caps, coats, etc., for sandbags and probably for Army shirts and towels.

An Adverse Report.

Before describing the method of cultivating and preparing the fibre, an adverse report on its possibilities should be noted, for it shows that some doubts exist concerning the future of nettle fibre even in Germany. A German agricultural expert states that the cost of production rules it out for purposes of cultivation, and will stand in the way of its general adoption, notwithstanding the fact that its cultivation is now a national necessity. In the first place, the only soil available is so-called fallow land—all other land being devoted to more profitable use - and the cultivation of this land demands an immense amount of labour such as no farmer in the Central Empires can afford without special aid. Not only must the land be ploughed, but each plant has to be placed into the ground separately, because the nettle, when cultivated, either loses its power of propagation by seed, or produces such a weak crop that it becomes of little use for fibre. This intensity of labour is required at the very time when farmers are engaged in preparing more valuable crops. The results of this authority's experiments in the use of the fibre in place of cotton were poor in the extreme, and he came to the conclusion that, while it is hopeless to look to farmers for an adequate supply of nettles, something might be done to stimulate the natural growth of the nettles on their natural soil by assisting the spreading of seeds, or by using prisoners of war for the cultivation of waste lands.

Cultivation in Germany.

The present cultivation in Germany is entrusted to a company established by men from the textile industry and agriculture, which is supervised by the Ministries of War and Agriculture. This company supplies plants and money free of interest to cultivators. The nettle is propagated by slips and from seed. The slips develop

more rapidly than the seedlings, but in shady woodlands seedlings grow even in the first year into strong plants, from which a crop can be gathered in October. Slips can be set in the spring and the autumn; seeds in the spring only. For slips the harvest may be two-fold—in July or August for the stems; in October for fodder.

German and Austrian authorities estimate that a sufficient area of land is available within the Central Empires to meet their needs and to permit of a large export trade. According to the Association for Forwarding Trade Activity (Berlin) the yearly raw material available from a plant yielding a quite practicable fibre which can be used as a substitute for cotton and jute (and which is presumably the stinging nettle), can be reckoned at 6,000,000 metric tons. In this connection it may be noted that in 1913 Germany imported 447,945 tons of raw cotton and 162,063 tons of jute.

By a Bundesrat Order of 27th July, 1916, the War Nettle Company fixed the price of stinging nettles for fibre at 14 marks per 100 kilogs. Subsequent evidence indicates that this rate is being paid for it, and that dried stinging nettle leaves, utilized for fodder and medicinal purposes, fetch 25 marks per 100 kilogs. The yield of fibre, again, varies from 10 per cent. in the case of wild nettles to as much as 30 per cent. in the cultivated plant.

Preparation of the Fibre.

In the method of preparation for spinning, which is adjudged best by the Royal Materials Testing Office, only nettles cut just above the ground are utilized. They are packed in bundles, dried, and the leaves removed. The stripping is satisfactorily done by the use of a lath set with nails in the form of a comb through which the stems are drawn lengthwise. After stripping, the stems are bundled. An Austrian manufacturer declares that a process of obtaining the fibre, devised by Dr. Richter of Vienna University, by steeping and roasting the stems, yields fibre which should take the place of flax, hemp, and of cotton. Dr. Richter's process appears to be carried out at ten factories in Bavaria, Silesia, and Alsace—that is, six rope factories, three jute factories, and a cotton-spinning mill.

The complaint against the process is that it is unsuitable for the production of the finer spinning stuffs, as it does not remove the wood from the fibre. A newer process, however, appears to have been discovered giving better results, and a great future is anticipated for the product.

Special machines have been built to deal with the fibre in the weaving industry. Several qualities of the stuff have been obtained by adding a suitable quantity of flax to the fibre. Moist-spun yarn up to No. 14 and dry-spun yarn up to No. 6, have been produced in large quantities in several factories.

Danish Experiments.

In spite of these somewhat optimistic opinions, it must be repeated that there is no clear evidence of the extensive adoption of the nettle fibre, even under present conditions, in Germany. Nevertheless the following independent and reliable account of Danish experiments confirms the view that the stinging nettle, as in Hans Andersen's tale of Elfride, may at any moment be convertible into shirts, and on a considerable scale.

In Denmark a Government Committee experimented with nettles, paying for them at the rate of 7 kr. per 100 kilogs. For textiles only the fibrous part of the plants is necessary, and of the three known methods of separating this from the rest of the nettle—the mechanical, the chemical, and putrefaction—the last-named is the one favoured by the Committee.

Methods of Treatment.

The treatment resembles the treatment of flax, and the main points of the method are :—

(i) The nettles are harvested in September and October and stacked like straw through the winter.

(ii) The tops and leaves are removed.

(iii) The stalks are rotted either (*a*) in a "retting dam" consisting of a wooden cage sunk in a lake or other natural water, or (*b*) in hot water. The former process takes fourteen and the latter four days with the water at a temperature of 30 degrees

centigrade. Experiments are still continuing to define the correct heat and time.

(iv) The stalks are dried in the open air.

(v) The stalks are cracked in a breaker.

(vi) The stalks are teased on a teasing board with a wooden knife.

(vii) The fibre is combed through a large iron comb or hackle, which finally removes all the remaining wood.

The fibre is then ready for the rope-walk or the spinning wheel.

One of the difficulties of the putrefaction process is the presence of bacteria. It has been discovered that there are two sorts prevalent—a beneficial and a harmful. It is said that the harmful species can be removed by steeping the nettles in running water for two to five hours before commencing to treat them. Experiments are being conducted in the pure cultivation of these bacteria with a view to finding a simpler method of putrefaction.

THE MANUFACTURED ARTICLE.

It has been found possible to make from nettle fibre fine rope, strong string, coarse linen, sail cloth, sacking and binder twine. Sheets, cycle tyre covers, and fine material suitable for clothing can also be made, but have not as yet been produced in Denmark owing to lack of expensive delicate machinery.

THE PROTECTION OF WHEAT FROM WEEVILS.*

THE problems affecting wheat storage or, as it might be more accurately described, wheat preservation, are of extreme urgency in view of the prospect of a serious shortage in the food supply of the world as one of the results of the war, and it is obviously a matter of exceptional importance to prevent, as far as possible, the destruction and loss of grain in store through the ravages of pests.

Recognizing this, the British Government asked the Royal Society of London to arrange an investigation into the damage done by insects to grain in store, throughout the Empire.

The Executive Committee of the Commonwealth Advisory Council of Science and Industry received, through the Prime Minister's Department, in October 1916, a request from the Royal Society that a committee should be appointed in Australia to co-operate with similar committees in England and Canada in this investigation. Reports were obtained from the Government Entomologists of each State, and it was shown that considerable losses were caused annually in Australia from grain weevils and other pests. The Executive Committee thereupon appointed a special committee to make further investigations.

This special committee included Mr. Leo Rossell, representing the milling industry; Professor W. A. Haswell, F. R. S., Professor of Zoology in the University of Sydney; and Mr. W. W. Froggatt, Government Entomologist, New South Wales. Mr. F. B. Guthrie, Chemist to the Department of Agriculture of New South Wales, subsequently joined the committee. The progress report prepared by this special committee has now been published in Bulletin 5 of

---

* Reprinted from the *Journal of the Department of Agriculture of South Australia* vol. XXI, no. 7, February 1918, p. 589.

the Advisory Council, and can be obtained post free from the Secretary, 314, Albert Street, East Melbourne.

The report indicates that only the two grain weevils (*Calandra granaria* and *C. oryzæ*) demand special measures on account of their destructive effects on stored grain, that the development of weevils in wheat and their increase in number may be checked by not using old bags which may be weevil-infested or storing in buildings likewise infested, and that bags of weevil-infested wheat should not be brought into contact or near that which is sound, for before wheat can become infested there must be a female to lay her eggs in the grains of wheat. It is only when the perfect insect, after going through the various stages of its larval existence, emerges through a tiny hole in the grain that the damage is evident, and except during the pupating stage destruction is going on during the whole life of the insect. Under suitable conditions it takes from 19 to 22 days from the egg to the adult beetle, and in three months, in one experiment, 40 weevils produced 3,056 descendants. Under the present system of handling wheat, the destruction of weevil, once it has gained access to the bagged grain, seems hopeless. Many methods of fumigating grain have been tried, and so far the most effective is that of poisoning with the fumes of carbon dioxide ; but with bagged wheat this is not applicable, save at a prohibitive cost. Sun-dried wheat contains only 4·7 per cent. of moisture. Neither in this nor in wheat as it emerges from the thresher with a moisture content up to 6·7 per cent. will weevil breed. With 8 per cent. of moisture they died in six weeks without breeding, at 9 per cent. they remained dormant, but with anything above the latter, provided they had free air, they became active and bred. It would thus appear that dry wheat stored in airtight bins is immune from the attack of weevils. Wheat when first bagged does not, under ordinary circumstances, contain sufficient moisture to enable weevils to breed ; therefore, unless moisture is added from without, the grain remains weevil-proof. Thus if stored in a fairly dry climate, completely protected from the weather, it is certain that wheat may be stored for an indefinite period without any damage from weevil.

THE IMPORTANCE OF MOLD ACTION IN SOILS.*

BY

DR. P. E. BROWN,

Iowa Agricultural Experiment Station.

THE development of soil bacteriology during the last decade has been truly remarkable. Many fundamental problems connected with the occurrence and activities of bacteria in soils have been attacked, and considerable progress has been made toward their solution. While much work still remains to be done along this line, results already secured show, in a rather definite way, the importance of bacterial action in soils from the fertility standpoint.

According to recent investigations, however, bacteria are not the only micro-organisms which exert an influence on soil fertility. Molds, protozoa, and algæ have been found quite commonly, and evidently their action, especially that of molds, must also be considered in determining the crop-producing power of soils. The subject of micro-organic life in the soil has therefore been considerably broadened and complicated.

The occurrence of molds in soils has been noted many times in the past in connection with bacteriological and other studies, and various investigations have dealt in a more or less general way with the action of these organisms. It is only within the last year, however, that an attempt has been made in a logical and comprehensive manner to study the occurrence, distribution, and activities of molds in soils, and to solve some of the fundamental

* Paper presented at the meeting of the Society of American Bacteriologists at New Haven, Conn., December 27, 1916, and printed in *Science*, vol. XLVI, no. 1182, dated 24th August, 1917.

problems which arise in connection with the growth of these organisms. The results secured at the New Jersey Agricultural Experiment Station, [1], [2], [3] not only furnish a basis upon which future experiments may rest, but they also indicate quite distinctly that the growth of molds in the soil may be of great significance.

The transformation of organic and inorganic compounds in the soil has long been considered the particular function of soil bacteria, but molds may also play an important rôle in such processes, and indeed it is conceivable that in some instances they may prove largely responsible for the simplification of complex soil materials.

It is not the purpose of this paper to review the previous studies on molds, for excellent bibliographies have been presented in the work of Waksman [2] and Coleman [1] already referred to. It is desired merely to call attention in a brief way to the varied action of molds in soils, and to present a compilation of various published data and some of our own unpublished results along this line, with the idea of emphasizing the need of further study of these organisms.

In the first place, the number of molds in soils should be considered, and while data along this line are far from conclusive, it has been shown that large numbers of these organisms are always present. Especially is this true for soils rich in humus and acid in reaction; but the occurrence of fungi is not restricted to such abnormal soils. Neutral, well-aerated, and well-fertilized soils are also found to contain rich mold floras. Furthermore, fungi are not limited merely to the surface soil, but occur in the deeper soil layers. The well-known predilection of certain fungi for acid conditions has been confirmed and leads to interesting conclusions regarding the special importance of these forms in acid soils in which beneficial bacterial action is largely restricted.

[1] Coleman, D. A. "Environmental factors influencing the Activity of Soil Fungi," *Soil Science*, vol II, no. 1, p. 1.

[2] Waksman, S. A. "Soil Fungi and their Activities," *Soil Science*, vol. II, no. 2. p. 103.

[3] Waksman, S. A. "Do Fungi actually live in the Soil and produce Mycelium?" *Science* n. s. 44, p. 320.

A very important point in connection with the occurrence of molds in soils has been studied recently by Waksman.[1] While the counting methods employed have shown the large numbers of molds in soils, considerable doubt existed as to whether these counts represented the actual number of active fungi, or only the spores. If spores alone are present, the activities of molds in soils may be of less immediate importance, although their presence would indicate previous active growth as well as future activity when the soil conditions become satisfactory for the development of active forms from the spores. Active mold growth on the other hand would undoubtedly be of immediate importance in the chemical changes occurring in the soil. The value of definite information along this line is apparent. The careful experiments of Waksman show that many molds occur in soils in an active state as well as in the form of spores. While certain groups do not appear to be present in an active condition in the soils tested, although the plate method showed their occurrence as spores, studies of other soils may lead to different conclusions.

Conn[2] has attempted to check Waksman's results by the use of smaller quantities of soil, but was unsuccessful. Using 10 mg. of soil, he secured no growth of mold mycelia such as Waksman obtained with lumps of soil 1 cm. in diameter. He describes a direct microscopic examination of soils and finds no mold mycelia present. He concludes from these experiments that there is serious doubt whether molds exist in soils in an active form *in sufficient numbers* to be important compared with bacteria. There seem to be two questions involved here: How large a proportion of the number of molds developing on plates represent active forms and how many spores? What is the number of active mold forms which need be present in the soil for them to be considered important in the various soil chemical processes?

The first of these questions is rather difficult to answer at the present time, but our experiments indicate that rather a large

[1] *loc. cit.*

[2] Conn, H. J., "Relative importance of Fungi and Bacteria in Soil," *Science*, n. s. 44, p. 857.

proportion of the total number of molds present in various soils occur in the active state. We have found active mold growth occurring in all the soils thus far examined, and we have used both Waksman's and Conn's methods. Our results confirm Waksman's observations, therefore, and Conn's criticism seems unwarranted, for *active mold mycelia have developed in all our tests, using not only 10 mg. but also smaller quantities of soils, as well* as the larger lumps employed by Waksman. The soils tested are normal soils, many of them untreated and none extremely rich in humus.

Further work along this line is certainly desirable, but from our observations thus far there seems no doubt but that *fungi occur actively in soils*, and hence we feel that their action must be important, regardless of their relative numbers compared with bacteria. Furthermore, the presence of spores is likewise important, for they may become active in the near future and bring about their characteristic reactions. The answer to the second question mentioned above can only come after long-continued experiments, but from the vigorous action of molds noted in so many cases, as will be pointed out later, it is evident that the problem of micro-organic activity in relation to soil fertility cannot be completely solved without a knowledge of mold growth. Perhaps they are not as important as bacteria, there is no means yet of knowing, but even if of secondary significance they deserve recognition. Our present knowledge of soil fertility is too incomplete to permit us to pass over hastily any possibly important factors without thorough study.

We believe, therefore, that molds occur in most soils, both in the active and in the spore state, and hence they must pass through their various life-cycles in the soil. Furthermore, different soils undoubtedly have different fungus floras. Species present under one combination of conditions may be absent under others. Organisms present only as spores in one case may occur actively in other instances. Finally, it seems perfectly possible that the relative occurrence of active and spore forms of various organisms may vary in the *same* soil with varying conditions of moisture, temperature, aeration, reaction, and food-supply.

Considering the occurrence of molds in an active state in all soils an established fact, the importance of these organisms in the decomposition of the soil organic matter becomes evident. Many experiments have been conducted along this line, and it has been very clearly demonstrated that molds are very efficient ammonifiers. Indications have been secured that there exists a correlation between the biological stage of the organisms and the periods of ammonia accumulation. The largest amount seems to accompany the periods of spore germination, and the smallest amount the time preparatory to actual spore formation.

All the nitrogenous organic materials which make up the humus content of soils are easily attacked by various fungus forms and ammonia is liberated in large amounts. Part of this ammonia may, of course, be utilized by them; but by far the larger part is set free and may be subsequently nitrified for use by the higher plants. Various fertilizing materials containing complex nitrogenous compounds may be ammonified by soil fungi, and their decomposition considerably facilitated. For instance, experiments with cyanamide show its rapid transformation to ammonia by certain molds. Ammonia production from urea by molds has also been definitely proven.

The non-nitrogenous portion of the soil organic matter is also attacked by many molds. Thus experiments have shown that cellulose is rapidly decomposed by many species, and other substances such as sugars, pectins, oils, fats, waxes, organic acids, etc., are likewise broken down by molds. Some recent results secured in our laboratories show the large carbon-dioxide production by molds. No doubt therefore remains but that these organisms play an extremely important part in the decomposition of all soil organic matter and indeed certain results indicate that their action along this line may be much greater than that of bacteria, at least under certain soil conditions.

No experiments have yet been reported which indicate that molds may bring about nitrification, and this process, therefore, still appears to be purely bacteriological. Further experiments may modify this conclusion.

Denitrification and deazotofication, however, processes now known to be of slight significance in normal soils but which may occur in highly manured, specially treated greenhouse and market garden soils, may possibly be brought about by the action of molds. The introduction of these organisms with the manure used may be an important factor here. Definite data along this line are lacking at the present time.

Non-symbiotic nitrogen fixation, or azofication by molds, has been studied from time to time, and indications have been secured that certain species may be able to utilize the nitrogen of the atmosphere. The results as a whole, however, are far from satisfactory, and indeed the conclusion has been drawn that at the present time the "weight of the conclusions on the fixation of nitrogen by fungi seems to be on the negative side." Further experiments along this line are certainly desirable.

The utilization of various nitrogen compounds by molds has been studied to some extent, and it has been found that ammonia and nitrate compounds are assimilated by these organisms in considerable amounts. Thus under extreme conditions of mold growth it is conceivable that molds may be actual competitors with the higher plants for nitrogenous food materials. It is not believed, however, that such conditions would occur except very rarely. A knowledge of mold growth in soils may be of some significance, nevertheless, in connection with the questions involved in the fertilization of soils with nitrates and ammonium salts.

The decomposition of mineral compounds in soils by molds has been studied only to a very slight extent. Data secured in our laboratories, very largely in connection with certain chemical and bacteriological studies, indicate, however, that these organisms may play an extremely important rôle, not only in preparing nitrogenous food materials for plants as has been indicated, but also in making other mineral constituents available. Complete data along the various lines indicated will be published later.

Studies of the production of available phosphorus by bacteria and molds have shown the vigorous action of various fungi in this direction. Several experiments carried out by various methods

have shown that rock phosphate is apparently transformed much more rapidly into a soluble form by many molds than by bacteria. The importance of further study along this line in connection with the solution of the moot question regarding the relative merits of rock phosphate and acid phosphate can readily be seen.

The oxidation of sulphur in the soil, or sulfofication, a process which has recently received some attention and which gives evidence of being of great importance from the soil fertility standpoint, has been shown to be accomplished by several species of molds. The action of these organisms in this process may become of special importance in connection with the recent suggestion for the production of available phosphorus by composting rock phosphate, sulphur, and soil or manure.

The process of ferrification, or iron oxidation in soils, while largely chemical in nature according to results thus far secured, is brought about partly by micro-organisms, and certain molds are apparently much more active in this action than any of the bacteria studied.

Experiments on the production of available potassium by molds should also yield interesting results. No data have yet been secured on this point.

In fact, it seems evident that mold action in soils may be of far greater significance than has previously been supposed in preparing available food for plant growth. No longer should the study of micro-organic activities in soils consider bacteria alone. Mold action must also be investigated, and in most cases it is undoubtedly true that only vague, incomplete results can be secured if such mold studies are not included. Many results secured in bacteriological investigations might be explained and interpreted much more clearly and definitely if the activities of molds were considered.

If soil bacteriology is to be developed to the proper extent in the future, and the relation of micro-organisms to soil fertility is to be established with any degree of certainty, investigations must include not only bacterial action, but the activities of molds and possibly also the growth of protozoa and algæ.

It is certainly desirable that the investigations of molds in soils and their activities and importance be carried out much more generally and on a larger scale than is the case at present. Here is a field of study rich in possibilities and the importance of work along these lines cannot be questioned.

NOTES ON MOTOR CULTIVATION.*

BY

JOHN McLAREN, Leeds.

As my name was mentioned in your paper last month in connection with the above matter, I take the liberty of sending you a few notes on the subject.

I have already expressed the opinion that trials of motor ploughs, in which British makers are unable to compete, are to be deprecated at the present time. All the English firms are over head and ears in munitions work, and can take no part in any such demonstrations during the continuance of the war. Of course, if the needs of the British agriculturist can be promptly and efficiently supplied by American makers, not even the British manufacturers would object, as we all recognize the importance of increasing our home food production. But in this case experts in land cultivation are satisfied that the British needs are not, and cannot be, satisfactorily met by the American product in which the commercial note, rather than the mechanical instinct, is the more obvious.

I take exception to the complacent assumption that any of the American tractors even approximately meets the requirements of British agriculture. If their efficiency and durability were on a par with the commercial skill with which they are boomed it might be different. British agriculturists are invited to take altogether too much on trust. Fortunately the results are not likely to be so financially disastrous to agriculturists as they would have been a year or two ago, seeing our farmers are now doing well, and most of them can afford to pay for their experience.

* Reprinted from *The Implement and Machinery Review*, October 1, 1917.

I state as a fact that motor-ploughs so-called, by which I mean ploughs hauled direct by internal combustion engines, have not been successful anywhere. In Canada where they have had the best chance, they have only done moderately, and even there, I believe, farmers are now returning to steam tractors. But even although they had been highly successful in Canada and elsewhere, it does not at all follow that they are as well suited for this country where farming conditions are essentially different. In most of the countries where motor tractors have been largely used the principal industry is corn growing, with little or no rotation of crops. Farmers are content to turn the sod over to a depth of 3 or 4 inches, and they require nothing of what we understand by the word "cultivation" in the proper sense of the word. There is nothing to correspond with our rotation of crops, and the land is never worked as in this country for cleaning or preparing the ground for root crops.

In our moist climate, moreover, the land is seldom suitable for carrying heavy motors, and it is quite an exceptional year where it remains hard enough to carry them for more than a very short season. Experience tells us that only heavy tractors are suitable for this country, because it is little use purchasing motors unless they can haul more than a two or three-furrow plough in light land as this can easily be done by horses. All the correspondents, even Mr. S. F. Edge, desiderate a light motor, but they naively confess that the trouble with light motors is that the wheels spin round and have not sufficient adhesion. It must be obvious to everyone that adhesion depends more upon weight than on power, and in order to haul even three or four furrows in moderately heavy land a motor of a minimum weight of 5 tons is essential.

In this country we require the land worked as well as ploughed, which involves cross-ploughing, cultivating, dragging and harrowing, and, in spite of all assertions to the contrary, this work cannot be done properly, efficiently, and economically by motors crossing and re-crossing the ploughed land.

I believe, in the last 50 years, about three million acres of land has either been laid down to grass or has laid itself down, and the problem to-day is to get this three million acres back again into

cultivation as quickly as possible. In the early seventies, before agricultural depression set in, there were thousands of sets of steam ploughing tackle in England and Scotland. They were of various systems, some worked by single and others by double engines. Most of them were owned by the farmers themselves, and they were practically all commercially successful. The changed conditions of agriculture in this country stopped all development of steam cultivating machinery, and as the tackle wore out it was not replaced, so that previous to the outbreak of war there was very little steam ploughing tackle in this country at all. When the food question became acute the Government realized the importance of the position, and set to work with the best means in their power to tackle it. The importation of immense quantities of American tractors appeared to them the best method of meeting the abnormal situation.

I am not going to criticize in a carping or unfriendly spirit the action of the Government who did what seemed to them best in a sudden emergency. The fact that mistakes were made is neither here nor there, because no great scheme can be carried through on the spur of the moment without serious mistakes, and if the result on the whole is satisfactory the public will not very seriously condemn any errors of judgment which may have been committed. The task before the Department was immense. Time pressed, and brooked no delay. Horses were not available. All our British engineers were engaged on munitions, and the most virile and capable of our man-power had either joined up or were conscripted to the colours. Seeing that we had practically no resources at home, there was no alternative but to look abroad, and the result we can all see.

It may be that the apparatus requisitioned by the Government has been helpful in meeting and tiding us over a sudden crisis, and if so we must not complain, but it is not to be thought of as a permanent solution of the question which faces us in the future.

Although British agriculturists, in years of cheap corn, allowed steam ploughing in England to die out, there has all along been a large business done in the manufacture of steam cultivating tackle for abroad, where it has been used for the production of corn to supply

food to Great Britain, whose rulers did not care a straw for agriculture and under whose policy it promised to become a lost art. There is therefore an immense amount of expert opinion and experience available if the Government choose to utilize it ; and it is very important that they should do so without delay, otherwise the country may come to the conclusion that these internal combustion tractors represent the last word and the final solution of the problem. But this is really not so, and it is obvious to all who are experienced in the cultivation of the land that there is a great danger of a wrong lead being given to our agriculturists in this matter. There is no reason why British agriculturists should not consult and take advantage of the practical experience of others, instead of purchasing it over again at their own expense. The old facts will be no more valuable to the country at large for having been discovered and proved afresh at a large expenditure of money and time.

But I do not wish to assume the rôle of a merely destructive critic. I should like in these notes to say something indicative of what I think would be the proper solution to the problem, which I may restate as follows :—(1) To turn over the three million acres of land in the least possible time and at the least possible expense ; (2) to make provision for working at the land and preparing a seed bed either for cereals or roots ; (3) economy of man-power. I do not care how this is done, whether by direct traction or by double engines (cable system worked by steam), or by internal combustion engines working on any system whatever. For the purposes of this letter I will assume that the whole three million acres have to be broken up by mechanical means, owing, if you like, to the shortage of horses. The figure is not important. Any other figure will do, as my conclusions will run out in the same proportion whatever figures we take as the basis of our calculation.

Assuming that the whole of this work was to be done by motor tractors such as we see being introduced at present, I suppose a liberal allowance per motor would be 300 acres of ploughing per season. This would mean 10,000 motors, at £350 per set, including ploughs—or £3,500,000 capital expenditure. From all the information

I can gather a cost of 30*s*. per acre would be considered a very favourable result, taking the average of all the motor sets put to work in the last two years, so that the cost of ploughing three million acres by motor at 30*s*. per acre would be £4,500,000. Each of these motors would require at least one skilled man to drive and attend to it. Many of them would require two men, so that I estimate at least 15,000 men would be required to work these 10,000 motors. But, in my opinion, the number required would be even more than that. Here, then, we have at least 15,000 men required to do the work, at a total cost of £4,500,000.

On the other hand, assuming the work of a pair of double engines at 3,000 acres per year, we should require 1,000 sets of tackle, costing, say, £3,500 per set. This runs out to £3,500,000, or exactly the same capital expenditure as for the motors. An outside figure of cost would be 15*s*. per acre, so that the cost of ploughing three million acres by double engines would be £2,250,000 —a difference in favour of steam of exactly one-half (£2,250,000). But the number of men called for to work the steam ploughing tackle would be only 2,000 skilled and, at the outside, 4,000 unskilled, making a total of 6,000 men required for the steam as against 15,000 for the petrol tractors.

Moreover, at the end of five years the bulk of the petrol tractor will be on the scrap-heap, and we shall be fortunate if at the end of that period 20 per cent. of them (or their depreciated equivalent) representing £750,000,are at work; whereas with the double engine cable system the engines will be almost as good as new, but, even allowing 20 per cent. for depreciation, they would represent a value of £2,625,000, which is probably the most important fact of all.

I have confidence in submitting these figures to the judgment of practical men, and do not think it is necessary to argue the question further. I shall be told that the tractor will do a great deal of farm work in addition to ploughing. In many cases it will and in many cases it will not; but whatever it earns in this way will only go a very small way towards the upkeep and redemption of the disappearing capital.

* * * * * *

STEAM AND MOTOR CULTIVATION.

THE remarks of Mr. John McLaren on motor cultivation, published in another column, are particularly welcome at the present moment, because they help to bring into proper perspective a generally distorted view of the rôle of motor tractors. When the value of the ploughing tractor first began to be recognized there was no suggestion that it would do the work efficiently accomplished by steam ploughing tackle, and if all the farms were of such size as to allow of the profitable use of steam ploughing sets there would never have been any question of employing motor tractors. It is because the vast majority of the farms, especially on the Continent, are of such moderate dimensions as to preclude the use of steam ploughing tackle that it was hoped to make up for the deficient supply of horses and men by the introduction of motor machines. Since the outbreak of the war the problem has become so serious that the economy of the motor tractor is of less importance than the necessity to till every available acre of land for the production of food-stuffs. This cannot be done by steam ploughing, or by horses, because there is not a sufficient number of them, and motor tractors are therefore the only machines available for the purpose. Their value is enhanced in a time of stress, whereas, if the necessity of cultivating the land were not so great, there would be plenty to say about the shortcomings of many of the existing types of motor tractors. These machines are anything but perfect, and there are some notable failures due to an ignorance of the limitations of the motor tractor and to a want of organization for enabling agriculturists to keep their machines in good running order ; but the tractor must be employed to put the available land under cultivation ; and, while doing useful work in a time of emergency, it is preparing the way for an accumulation of practical experience which should be valuable to tractor designers after the war. Many of the direct ploughing tractors now in the use are inefficient, and few can plough three furrows to a depth of a foot, while on stiff clayey soil they are frequently unable to go deeper than a few inches. On some soils, and on very hilly land, they are sometimes hopeless, and this is one

of the weak points of the tractor, which should be so designed as to be capable of ploughing to a suitable depth on all kinds of soil. Still, in the present condition of the agricultural industry, the tractors are rendering a great service in tilling large areas of land that otherwise would be allowed to lie fallow. When conditions change after the war the tractors will have to be designed on quite different lines, preferably with chain tracks, for after all the question is mainly one of reducing the dead-weight as much as possible and distributing it over a considerable area of contact with the soil. There is no doubt that the tractor in some form or another has come to stay, and its success after the war will depend upon its being improved, perhaps to a considerable extent, to meet the needs of agriculturists who have to till moderately-sized farms. The tractor can only be successful in two ways, either in being employed for purely tillage operations by contractors who operate over particular districts, or in adapting it to many kinds of farm work so that the agriculturist can purchase a machine with the certainty of being able to use it during the greater part of the year. Steam ploughing tackle does not come within this sphere of operations, nor can the tractor compete with steam when it comes to breaking up big lands or deep ploughing on large estates.

Notes.

Dr. C. A. Barber, Government Sugarcane Expert, Madras, writes in the January (1918) number of the *International Sugar Journal* on the **Origin of the Uba Cane** as follows :—

The reference in your September number to the origin of the Yuba or Uba cane, so largely grown in Natal, gives me an opportunity to put down certain notes which I have accumulated on this variety and which may be of interest to those who cultivate it. I have grown it now for a considerable number of years on the Cane-breeding Station at Coimbatore in company with a large assortment of indigenous Indian canes. The Yuba in the collection has been obtained direct from Natal. There is no doubt whatever that it is a Ganna cane of the Pansahi group of Indian canes, a series which is grown in many places from Assam to the Punjab, a distance of over 1,200 miles along the Himalayas, but it is perhaps best suited to Bihar where there are a number of canes of this group. I made some attempt at locating Yuba, but I failed completely in coming across any Indian language with *uba* in it. I have thus far collected the following varieties, differing from one another to a very slight degree :—Sadi Khajee said to come from Assam, Pansahi, Maneria, Lata, Chynia, and Ketari from Bihar; Merthi, Dikchan, Sanachi, Baranga from the United Provinces, and Kahu from the Punjab. It is interesting to note its greatest development in Bihar, for this is on the border line between the regions where thick and thin canes predominate, and Ganna canes as a class are intermediate between the Paunda or thick tropical ones, and the Ukh or thin indigenous Indian canes. I must therefore first of all emphasize that Yuba is an indigenous Indian cane, leaving for the present the way in which it reached Natal, although I see that there is a strong presumption

from its history that it came from an Indian source. My main difficulty has been to find any connexion between the word Uba and any Indian language.

On a recent visit to Burma, I examined carefully all the canes collected on the farms and many in the fields. As in Assam and the Peninsula, thick canes grow very well in Burma and for a time I failed to get any indication of indigenous canes such as are grown in India occurring there. But on a visit to Hmawbi farm, I was shown a thin cane which is grown in Moulmein. They had fortunately, also growing, Yuba canes received from Natal. Now the first glance showed that the Moulmein cane was a member of the Pansahi group, and a little further examination also showed that there was no obvious means of distinguishing the Moulmein cane from the Yuba growing next to it. My language difficulty at once occurred to me, and I asked whether there were any other words in Burmese which sounded like Yuba. The reply was interesting : "Oh yes, of course, 'u-ba' means 'take it'." It is the usual answer of the polite Burman (who will give you anything) to any request made on going round his fields. So the following suggestion may be made. Governor Mitchell would very likely in those days leave a Burmese port when returning to Natal. He would see the canes and ask for a few, receiving the characteristic "u-ba" in reply. I give the suggestion for what it is worth, but would emphasize the fact that the cane in question is most certainly an Indian indigenous cane of the Pansahi group.

I have often wondered at its being grown in Natal and Queensland. It is a cane of poor sucrose content in India, but it is thickish as Indian canes grow. It is very resistant to salt in the soil as are all of its class, moderately fibrous, very luxuriant, and tillering well. But, under the ryot's cultivation, often on entirely unmanured and badly cultivated land, it and its class have suffered heavily from red rot (*Colletotrichum falcatum*) and have been displaced by thinner and more hardy canes over large tracts. Its use as a fodder I can readily understand in places where sorghum cannot easily be grown and grass is not abundant. It requires little water and is much asier to grow on poor land than the thick canes of the tropics,

especially where the climate is cold and the growing season short. But, where such canes are desirable and the rich thick canes of the tropics are grown with difficulty, I sometimes wonder whether India may not be able to provide a better cane for the mill. We do not regard the Pansahi class at all as our best indigenous varieties. On the Cane-breeding Station we have taken various members of the Pansahi group as parents in our crosses and have, I believe, succeeded in getting hybrids with tropical canes. The work is still in progress, but the luxuriance and free tillering of the class makes it desired in this combination. The Natal planters would be well advised to try a number of thin canes of good sucrose content which we have already obtained on the Cane-breeding Station, and I shall be happy to send consignments if they wish it.

***

TEN YEARS OF AGRICULTURE THROUGHOUT THE WORLD.

In dealing with the statistics of agriculture, even more particularly than in reviewing those relating to other matters, the wide variety of crops, of climate, of terms employed, makes it exceedingly difficult to draw up any estimates of production that are beyond cavil. In the course of the nineteenth century many efforts were made to accomplish this aim, but in order to reach a practical and tangible result it became necessary to create a central organization of high standing, specially arranged for the collection and scientific classification of the very miscellaneous data which are published in so many parts of the world. This central organization is the International Institute of Agriculture, Rome, so well known to competent authorities by its numerous publications, and has just issued a new work dealing on a complete and accurate basis with the world's agriculture.

This volume is the *International Year Book of Agricultural Statistics, 1907 to 1916*, and is the most exhaustive work in existence on agricultural statistics, as it is the result of very extensive and detailed research devoted to this study.

Comprising over one thousand pages, the 836 statistical tables are replete with every sort of information upon the subjects considered, thus establishing the volume as one of very great importance.

The number of agricultural products embraced is very large and those of tropical countries have received as much attention as the crops of the temperate zones have secured.

In due sequence are furnished all the available data regarding areas cultivated in each country, the total yields realized, and the yields obtained on a given standard of area. Besides all this the Year Book includes the five years' and ten years' averages for the period included, so that readers can ascertain at a glance whether in any particular year cultivation has extended or has been restricted in a given country and whether the results have been favourable or the reverse.

The first products to be considered are the cereals as naturally being of capital importance for food, the very basis of human requirements inasmuch as they furnish our daily bread.

We find that the ascertainable annual yield of wheat throughout the world exceeds a thousand million quintals, and represents at present value more than two thousand millions sterling ; the yield of maize is nearly as large as that of wheat and is worth one thousand millions sterling, while the aggregate value of the six chief cereals (wheat, rye, barley, oats, maize, and rice) is not less than six thousand millions sterling, or thirty billions of dollars, yearly.

The yield of potatoes is over fifteen hundred million quintals, and that of sugar beet is more than five hundred million quintals. Every year the world has at disposal a total of 150 million quintals of beet and cane sugar, nearly 150 million hectolitres of wine, 10 million quintals of coffee, more than 8 millions of leaf tobacco, nearly 1 million quintals of hops.

Textile industries account annually for nearly 50 million quintals of cotton, 8 millions of flax, 7 millions of hemp, while silkworm breeders in Europe and Asia deliver to the trade more than 200 millions in cocoons. The raw material for vegetable oils comprises yearly throughout the world an aggregate of 30 million quintals

of olives, and a similar quantity of linseed, 4 millions of hempseed, and 5 millions of rapeseed.

Turning to live stock, we find in the Year Book, for each of the ten years comprised, the numbers of horses, asses, cattle, sheep, pigs, etc., in 82 countries taken singly, and afterwards reckoned out as compared with each thousand inhabitants of the country, both at the opening and at the close of the period under review. The results reached in these tables are of the greatest interest. It appears that in Uruguay there are eight head of cattle to each inhabitant, in Argentina more than four head, in Australia more than two head, and throughout South America about two head per inhabitant, while in the United States and Canada there is one head of cattle per person, and in Europe only one to two persons.

Having given, by means of a large number of tables, the imports and exports of the products previously considered as to yield, and shewing the origin and destination of these imports and exports as regards each country, the Year Book takes up the question of consumption, also for each country.

It is worth while to note that the consumption of wheat per head of population is extremely large in Australia, in Canada, in France, in Argentina, etc., while it is very limited in Japan, British India, Egypt, Sweden, etc., as the inhabitants of these countries live chiefly upon rice, maize, rye, or other articles of food.

The prices of the chief products, on spot and for forward or future delivery, form a special chapter where readers will find all the data for a detailed examination of the marked fluctuations in recent years, inasmuch as weekly quotations are recorded in respect of the chief products. This chapter comprises tables of rates of freight and of exchange.

Then follows a chapter on fertilizers and chemical products employed in agriculture, including the data of production, trade, and consumption, with the quotations for phosphatic, potassic, and nitrogenous fertilizers, for sulphur and sulphate of copper. These materials give rise to a very large and active trade, since many of them are only to be found at certain spots, and therefore whole fleets are in request for their transport to the localities where they are

consumed. This is particularly the case with natural phosphates and with nitrate of soda.

At the conclusion of the Year Book there is a special chapter where readers can ascertain the authority for each of the data, and are thereby enabled, if they so desire, to consult these authorities and to verify the figures.

This important work is indispensable for all who wish to study any point connected with agriculture or with the trade in agricultural products. It has its special place on the desk of the economist, of the agricultural engineer, of the merchant, of the manufacturer, of the statesman, in short of all who are interested in the progress and well-being of nations.

The price of the volume is 8s, or $2. It is available at the Service des abonnements et publications de l' Institut International d'Agriculture, Villa Umberto, Rome, Italy.

***

THE **Water Hyacinth,** which has become so great a pest in Bengal and Burma that it has been found necessary in the latter province to pass a special law to deal with it, has also been found in the neighbourhood of Gurdaspur. It is said that its introduction there a few years ago was due to a Deputy Commissioner who wished to beautify his tank. It spread over the tank with great rapidity, and passing cultivators, attracted by its beauty, took away plants to put in their own tanks which in turn it soon covered. It is of course impossible that the plant should ever be the pest here (in Punjab) it apparently is in more watery provinces, but the attention of the members of the local agricultural association has been directed to the necessity of doing what they can to prevent it spreading.—[*Punjab Agricultural Notes*, March, 1918.]

***

THE COTTON-SEED INDUSTRY.

THE development of the Indian cotton-seed trade practically dates from the beginning of the present century, and the annual production of cotton-seed in India is now estimated at 1,870,000 tons,

of which 1,168,000 tons are available for cattle food and crushing purposes. The Indian seed belongs to the class known as white or fuzzy seed as it has on it a double layer of fibre, the underlayer of fluff or lint and the outer layer of true cotton fibre. The seeds, as they come into the market, contain considerable quantities of impurities and also about 8 per cent. of damaged seeds, these being due to careless ginning. The composition of a number of Indian seeds gives an average of 19·67 oil, 34·68 meal, and 45·65 of husk and lint. Indian seed is valued in this country on the basis of 18 per cent. of oil, but there is evidence to support the percentage being raised. The most effective treatment of the cotton-seed for storage and the prevention of fermentation appears to be to delint it immediately after ginning, and remove all light and broken seeds, and thoroughly clean them and sterilize them by hot air blasts in vertical cylinders or spiral conveyors on the counter-current principle. Seeds thus treated and stored in a dry godown, or in silos, keep well for a very long time and yield excellent products. With regard to the extraction of oil, the best method for Indian seed is the mixed decorticated plan. The American practice is to remove the lint, decorticate the seed, and then crush the kernels separately, but it is better to modify this process by the admixture of a certain percentage of ground hulls with the kernels. The very small oil-content of the seed has made it necessary to devise means to obtain a maximum yield of oil from the seeds, and various proposals with a view to this object being attained have been tried. The refining of the crude oil is also a process of importance in this respect.

Of the by-products, the hulls are the most important, being utilized as fertilizers, feeding stuffs, and as raw materials for paper-making. Next in importance is the liquid residue or foots. This has been used to produce colouring matter, paint, soap, stock, shellac substitute, and, with a considerable admixture of other substances, as a leather substitute. The lint separated in the preliminary process is used for making paper, cotton oil, gun cotton, celluloid, artificial silk, etc. There are still a few problems to be solved in connection with the Indian cotton-seed industry, and, besides the desired increase in the oil-content, the separation of the

fluorescent substance found in the oil is desirable, and the effect of cotton oil on press cloths of different types invited consideration.

* * * * * * * * * *

A strong seed-crushing industry should be established in this country, so that the fertilizing by-products might be returned directly to the land from which they had been derived.—[*Indian Industries and Power*, vol. XV, no. 6.]

***

THE **Statistics** compiled by the Government of India from the Reports **of the Provincial Civil Veterinary Departments** for the year 1916-17 reveal the great expansion of the departments and the wider appreciation of the good work done by them during the last twelve years. The expenditure of over Rs. 31 lakhs during the year as against some Rs. 10 lakhs in 1904-05 shows that Government is fully aware of the importance of cattle to India inasmuch as without them agriculture would be at a standstill, and in spite of his innate conservatism the Indian peasant has not been slow to take advantage of the greater facilities provided for keeping his faithful slaves at the plough in fit condition. Though the number of dispensaries increased from 269 to 463 (an increase of 72 per cent. only), the number of animals brought for treatment rose from 256,014 to 954,599 (an increase of nearly 300 per cent.). The number of animals treated and castrations performed by peripatetic veterinary assistants similarly increased by about 200 per cent. (from 258,718 to 750,948). Inoculation, once so dreaded, has grown so popular that, whereas twelve years ago owners of only 75,269 cattle could be persuaded to allow their animals to be treated, last year the owners of as many as 644,841 were found to be believers in the immunity afforded by the various sera manufactured at the Muktesar Laboratory. That this increasing confidence has not been misplaced will be apparent from the fact that in a year in which 255,418 animals died from contagious diseases, only 2,668 died after inoculation out of more than 600,000 treated.

Improvement of stock by maintenance of stud bulls and horse and donkey stallions, cattle-breeding farms and holding of fairs and shows, is another line of activity of the Department. The number of stud bulls, owned both by Government and local bodies, rose from 1,197 in the previous year to 1,357 during the year under review, but it is a pity that local bodies, outside the Punjab and parts of the United Provinces, have not yet realized their usefulness in this direction. The receipts of cattle farms amounted to Rs. 1,60,078 of which the Hissar farm alone contributed Rs. 1,24,853. Two hundred and seventeen cattle fairs and shows were held during the year and 24 medals and prizes worth Rs. 18,645 were awarded.

It is clear that to cope with the increasing amount of work thrown on the Department as the result of a growing appreciation on the part of the cultivators and others, more rapid provision of the supervising staff and trained subordinate staff is required. It appears however that the career of a veterinary assistant does not appeal to the professional classes of some provinces at least, as in spite of liberal provision of scholarships and almost a sure chance of getting an appointment at the end of the training the number of entrants in veterinary colleges and schools is so limited. Rs. 4,18,571 were spent on veterinary instruction during the year, but the number of students turned out at the end of the year as qualified for employment as assistants was only 137 for the whole of India.—[EDITOR.]

***

SPIKE DISEASE IN SANDALWOOD.

THE *Indian Forester* for February (1918) has two interesting papers on the subject of spike disease in sandalwood, the root cause of which remains as elusive as ever. There is no hint of its being eradicated from any area in which it has established itself, but there are always ominous accounts of its cropping up even in practically isolated spots. In the Kollimalai Hills, for instance, we are told there was no trace of the disease up to the middle of 1912; in

April, 1914, a single sapling was discovered to be infected; in October of the same year a number of young trees had been found to be attacked and some dead, and so the Forest Officer had all the diseased trees he could find uprooted. The spread of the disease was, however, not arrested. The extraordinary feature of the disease is that it appears in isolated patches—in the Kollimalai Hills there were two affected areas eight miles apart, while the intervening tract remained unaffected. More remarkable still is the fact that the nearest previously known spiked area from the Kollimalais was 80 miles away and no explanation is forthcoming as to how this distance was bridged. The idea is beginning to gain ground that the disease is endemic and spontaneous and may be spread by seed. It is remarkable that though first discovered in Coorg in 1899 and closely studied ever since, no progress has been made in arresting the disease.—[*Indian Engineering*, March 16, 1918.]

***

SILK CULTURE IN INDIA.

THE trade in raw silk from India has seriously decreased within the past fifty years, largely in consequence of the deterioration of the Bengal cocoon and inferior reeling. At the present time the main quantities of Indian silk are grown in Kashmir where sericulture is a State monopoly. Kashmir ordinarily produces each year about 1,400 bales of 150 lb. each. The silk is grown on the Himalayan foothills at an altitude of 6,000 feet. It is regular, well-reeled, and although slightly weaker in the thread than Italian silk, nevertheless compares favourably with the Japanese qualities. The greatest care is taken to prevent disease in the cocoons. Good seed is imported each year from the Cevennes district of France, and reproduction is not allowed.

The silk is reeled within the borders of the State, and although there is some export of cocoons to Italy, there is no reason why the whole of the season's crop should not be reeled in Kashmir. The production of cocoons is large and could be extended, but increased

facilities for reeling under European supervision are required in order to secure the advantages of the low-priced and comparatively highly-skilled labour. The Kashmiree is a skilful operative, and with European supervision, the reeling is almost as good as the Japanese.

The prospects for the extension of sericulture in India are promising. It must be borne in mind that the finest qualities of silk which the world produces are grown in the hilly districts of countries like China, Japan, and Italy, the climate and altitude apparently producing nerve, strength, and vitality in the fibre grown on the hills which is not apparent in the silk produced on the plains.

There is little doubt that the foothills of the Himalayas lying within the United Provinces and the Punjab and the States of Bhutan, Sikkim, and Nepal, are as well adapted to sericulture as those lying within the State of Kashmir. The population of these districts is almost equal to, and the area is considerably greater than, the whole of Japan. The main desideratum is a spirit of enterprise similar to that shown by the Government of Kashmir, and it would appear that efforts should be made by the Indian Government to encourage the development of sericulture within this large area.

Within the past two years sericulture has been commenced within the State of Patiala on a small but definite basis under the supervision of a native graduate of the Montpelier School in France. The first parcels of raw silk which have reached this country have been declared by experts to be fully equal to the best Kashmir silk.

The Bengal export trade has almost ceased. The cocoon is not a good one, and careless reeling produces an irregular silk only suited for coarser manufactures. There is little doubt, however, that were the industry developed under qualified supervision, a greatly improved quality would be produced.—[*Report on Silk and Silk Waste by the Departmental Committee appointed by the Board of Trade.*]

INDIGO CESS ACT.

THE following Act of the Indian Legislative Council received the assent of the Governor-General on the 6th March, 1918 :—

ACT NO. III OF 1918.

An Act to provide for the levy of a cess on indigo exported from British India.

Whereas it is expedient to provide funds for the promotion of research in the interests of the indigo industry in India ;

And whereas for this purpose it is expedient to levy a cess on indigo produced in India and exported from British India ; It is hereby enacted as follows :—

Short title and commencement.

1. (1) This Act may be called the Indigo Cess Act, 1918 ; and

(2) It shall come into force on the first day of April, 1918.

Imposition of duty on exports of indigo and preparations thereof.

2. (1) There shall be levied and collected on all indigo produced in India and exported from any customs-port to any port beyond the limits of British India or to Aden a cess at the rate of one rupee per maund of $82\frac{2}{7}$ pounds avoirdupois :

Provided that, where any preparation of indigo mixed with any other substance for use as a dye is so exported, the cess shall be levied on such proportion of the total weight of such preparation as the Governor-General in Council may determine by rule under this Act.

(2) In this section the expression "customs-port" has the same meaning as in the Sea Customs Act, 1878, VIII of 1878, and the cess levied shall be deemed to be a customs-duty for the purposes of Section 5 of the Indian Tariff Act, 1894 (VIII of 1894).

3. The proceeds of the cess collected under this Act shall be applied to meet the cost of such measures as the Governor-General in Council may consider it advisable to take for promoting research in the interests of the indigo industry in India.

Application of proceeds of cess.

4. The Governor-General in Council may make rules consistent with this Act—

Power to make rules

(*a*) for regulating the method of assessing, levying and collecting the cess;

(*b*) for prescribing the particular purposes to which the cess may be applied; and

(*c*) generally for carrying out the purposes of this Act.

***

IT is notified that **Cess** at the rate of one rupee per maund will be levied, with effect from the 21st May, **on all Indigo exported from Travancore** to any port outside British India or to Aden.

***

RULES FOR DISINFECTION OF PLANTS.

IN exercise of the power conferred by sub section (1) of section 5 of the Destructive Insects and Pests Act, 1914 (II of 1914), the Bengal Government has made the following rules for the disinfection of plants in respect of which Notification No. 13-C.,[1] dated the 7th November, 1917, has been issued under sub-section (1) of section 3 of that Act, by the Governor-General in Council, namely :

1. It shall be the duty of the Customs staff to conduct the operation of disinfection of plants on their entry at the port of Calcutta.

2. The fumigation of plants on their entry at the port of Calcutta with hydrocyanic acid gas shall be in accordance with the instructions received from time to time from the Imperial Entomologist, Pusa.

---

[1] See *The Agricultural Journal of India*, vol. XIII, part II, p. 359.

REGULATION OF IMPORT OF PLANTS BY POST.

A Notification, dated 15th December, 1917, issued by the Government of India in the Department of Commerce and Industry, says :—

In exercise of the powers conferred by section 25 of the Indian Post Office Act, 1898 (VI of 1898), as amended by Act III of 1912, the Governor-General in Council is pleased to empower the postal officers noted in the margin to search, or cause search to be made, amongst all articles in course of transmission by post to any place in British India, for living plants and all portions thereof (including seeds and fruits) the import of which by sea or land into British India is prohibited, regulated or restricted by the Notification in the Department of Revenue and Agriculture No. 13-C.,[1] dated the 7th November, 1917, and to direct that the said officers shall deliver all postal articles reasonably believed or found to contain such goods to the nearest Customs Collector.

1. The Presidency Postmaster, Deputy Postmaster and Assistant Postmasters at Bombay.
2. The Postmaster and Deputy Postmaster, Karachi.
3. The Presidency Postmaster, Deputy Postmaster and Assistant Postmasters at Calcutta.
4. The Presidency Postmaster, Deputy Postmaster and Assistant Postmasters at Madras.
5. The Postmaster and Deputy Postmaster, Dhanushkodi.
6. The Postmaster, Negapatam.
7. The Postmaster, Deputy Postmaster and Assistant Postmasters at Rangoon.

***

In continuation of the Department of Revenue and Agriculture Notification No. 13-C. publishing rules issued by the Governor-General in Council under section 3 (1) of the Destructive Insects and Pests Act, 1914 (II of 1914), printed in the last April issue of this Journal, it has been decided that the licenses required, under section 10 of the Notification, for the **importation of flax seeds and berseem** (Egyptian clover) **seeds into British India by sea** should be granted to the consignees by the Provincial Department of Agriculture only after the Department has satisfied itself that the seed has been obtained through well known and reliable seed merchants and has been guaranteed free from dodder seeds.

[1] See *The Agricultural Journal of India*, vol. XIII, part II, p. 359

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

THE Birthday Honours' List contains the following which will be of interest to the Agricultural Department :—

To be C.S.I. The Hon'ble Mr. Henry Stavely Lawrence, I.C.S., Commissioner in Sind, Bombay (formerly Director of Agriculture, Bombay).

The Hon'ble Mr. Llewellyn Eddison Buckley, I.C.S., Commissioner of Revenue Settlement, Survey, Land Records and Agriculture, Board of Revenue, Madras.

To be C.I.E. Dr. Charles Alfred Barber, Government Sugarcane Expert, Madras.

Nasarwanji Navroji Wadia, Esquire, Bombay, Member of the Indian Cotton Committee.

Khan Sahib. M. Mahommad Ikramuddin, Farm Overseer, Agricultural Research Institute, Pusa.

Rao Sahib. Chintamani Srinivasa Gopaul Krishna Rao, B.A., Superintendent, Office of the Agricultural Adviser to the Government of India, Pusa.

THE names of the undermentioned have been brought to the notice of the Government of India for valuable services rendered in India in connection with the war up to the 4th August, 1917.

Mr. J. Mackenna, C.I.E., I.C.S., Agricultural Adviser to the Government of India and Director of the Agricultural Research Institute, Pusa.

Mr. D. A. D. Aitchison, M.R.C.V.S., Principal, Madras Veterinary College, Madras.

Mr. K. Hewlett, Principal of the Veterinary College and Hospital, Bombay.

Mr. N. N. Wadia, Mill Owner, Bombay (Member of the Indian Cotton Committee).

Colonel J. Farmer, C.I.E., Chief Superintendent, Civil Veterinary Department (Punjab).

Mr. W. C. Renouf, I.C.S., Political Agent, Bahawalpur (formerly Director of Agriculture, Punjab).

***

MR. T. F. MAIN, B.Sc., Deputy Director of Agriculture, Sind, was granted, in Bombay Government Order No. 5372, dated 7th May, 1918, combined leave up to the 6th July, 1918, made up of privilege leave for one month and 7 days and special leave for the remaining period. He availed himself of the leave with effect from the forenoon of 4th June.

Mr. Gul Muhammed Abdul Rahman, Divisional Superintendent of Agriculture in Sind, has been appointed to act for Mr. Main.

***

LIEUTENANT-COLONEL G. K. WALKER, C.I.E., F.R.C.V.S., Superintendent, Civil Veterinary Department, Bombay Presidency, has been granted privilege leave for three months in combination with furlough for three months, with effect from the 30th March, 1918, or the subsequent date on which he may avail himself of it.

Mr. G. Taylor, M.R.C.V.S., Indian Civil Veterinary Department, Punjab, has been appointed to officiate as Superintendent, Civil Veterinary Department, Bombay Presidency, during the absence of Lieutenant-Colonel G. K. Walker on leave or until further orders.

***

MR. G. A. D. STUART, I.C.S., Director of Agriculture, Madras, was granted privilege leave for one month from or after the 1st May, 1918.

The following arrangements were made in consequence of the grant of this leave :—

Mr. R. W. B. Cecil Wood, M.A., Principal and Professor of Agriculture, Agricultural College, and Superintendent, Central Agricultural Station, Coimbatore, to act as Director of Agriculture, Madras.

Mr. William McRae, M.A., B.Sc., Government Mycologist, Madras, to act as Principal of the Agricultural College, Coimbatore.

Mr. D. Ananda Rao, B.Sc., Assistant Professor of Agriculture and also Assistant Principal of the Agricultural College, to act as Professor of Agriculture and Superintendent of the Central Agricultural Station, Coimbatore.

***

MR. R. D. ANSTEAD, Deputy Director of Agriculture for Planting Districts, was granted privilege leave for one month from 1st April, 1918.

***

MR. W. MCRAE, M.A., B.Sc., Government Mycologist, Madras, was granted privilege leave for one month with effect from or after the 2nd June, 1918.

M. R. Ry. S. Sundararaman Avargal, M.A., Assistant in Mycology, was appointed to act as Government Mycologist during the absence of Mr. W. McRae.

***

M. R. Ry. D. BALKRISHNA MURTI GARU, Assistant Director of Agriculture, 1st Circle, Madras Presidency, has been appointed to act as Deputy Director of Agriculture and to continue to be in charge of that circle.

***

MR. G. R. HILSON, Deputy Director of Agriculture, I, II and III Circles, Madras Presidency, has been appointed to be Deputy Director of Agriculture, II and III Circles.

DR. R. V. NORRIS, M.SC., A.I.C., formerly Physiological Chemist, Muktosar Laboratory, has been appointed to the Indian Agricultural Service, and posted to Coimbatore as Agricultural Chemist to the Government of Madras.

***

THE combined leave for one year granted to Mr. N. S. McGowan, Professor of Agriculture, Sabour College, has been cancelled.

***

MR. G. MILNE, I.C.S., Director of Agriculture, Bihar and Orissa, is appointed to be the Director of Civil Supplies, Bihar and Orissa, in addition to his own duties. He is also appointed to be Custodian of Enemy Property during the absence on deputation of Mr. B. A. Collins or until further orders.

***

MR. C. SOMERS TAYLOR, B.A., Offg. Principal of the Agricultural College at Sabour and Agricultural Chemist to the Government of Bihar and Orissa, has been granted privilege leave for two and a half months from 1st May, 1918, or any subsequent date on which he may avail himself of it.

Babu Manmatha Nath Ghosh, Assistant Professor of Physics and Chemistry, Sabour Agricultural College, is appointed to hold charge of the current duties of the Agricultural Chemist to the Government of Bihar and Orissa in addition to his own duties during the absence on leave of Mr. Taylor.

Mr. N. S. McGowan, Professor of Agriculture, Sabour College, has been appointed to officiate as Principal of the College during the absence on privilege leave of Mr. Taylor.

***

THE services of Mr. B. A. Collins, Registrar of Co-operative Societies, Bihar and Orissa, and Controller of Munitions, Bihar and Orissa Circle, are placed temporarily at the disposal of the Government of India, Indian Munitions Board.

MR. R. W. D. WILLOUGHBY, I.C.S., Registrar, Co-operative Societies, United Provinces, has reverted as Deputy Commissioner, Second Grade, and has been posted to Kheri.

Shaikh Maqbul Husain, Khan Bahadur, C.I.E., Joint Registrar, Co-operative Societies, United Provinces, officiates as Registrar, *vice* Mr. R. W. D. Willoughby.

***

MR. H. M. LEAKE, Economic Botanist to Government, United Provinces, and Officiating Principal, Agricultural College, Cawnpur, was granted privilege leave for 20 days with effect from the afternoon of 10th June, 1918.

***

MR. JATINDRA NATH SEN, M.A., F.C.S., Supernumerary Agricultural Chemist, on special duty at Cawnpur, was granted privilege leave for one month and 13 days with effect from the forenoon of 3rd April, 1918.

***

MR. A. W. FREMANTLE, formerly Principal, Agricultural College, Cawnpur, has been permitted to retire from the Indian Agricultural Service.

***

THE work of the Punjab Department of Agriculture has increased so much that a second Director has been sanctioned for the period of the war. The Hon'ble Mr. C. A. H. Townsend, who was the Director of Agriculture and Industries of the Province, has made over the Agricultural Section to Mr. E. A. Joseph, I.C.S., and retains the portfolio of Industries himself.

***

MR. G. EVANS, Deputy Director of Agriculture, Central Provinces, has proceeded to Mesopotamia on special duty in connection with the development of agricultural resources there.

MR. C. P. MAYADAS, Assistant Director of Agriculture, Southern Circle, Nagpur, is transferred in the same capacity to the Western Circle, Akola.

***

THE services of Mr. T. Couper, M.A., I.C.S., Director of Agriculture, Burma, have been placed at the disposal of His Excellency the Commander-in-Chief.

Mr. A. E. English, C.I.E., I.C.S., Commissioner on special duty, is placed in charge of the current duties of the Office of Director of Agriculture, Burma, in addition to his own, *vice* Mr. T. Couper.

The Local Government has also directed him to assist the Registrar, Co-operative Societies, Burma, in addition to his other duties, and has conferred upon him all powers of a Registrar under the Act.

***

THE services of Mr. E. Thompstone, Deputy Director of Agriculture, Burma, are placed at the disposal of His Excellency the Commander-in-Chief in India with effect from the 1st May, 1918.

Mr. F. J. Warth, M.Sc., Agricultural Chemist, who was appointed Assistant Commandant of Military Police last March, has temporarily reverted to the Agricultural Department and is appointed to officiate as Deputy Director of Agriculture, *vice* Mr. Thompstone.

THE services of Maung Ba Gyaw, Temporary Engineer, Public Works Department, who was appointed as an Agricultural Engineer, Burma, have been re-transferred to the Public Works Department of the Province with effect from the 17th May, 1918.

***

THE following officers have been appointed to serve on the Food-stuffs Sub-Committee of the Central Transport and Food-stuffs Board formed at the headquarters of the Government of India

and presided over by the Hon'ble Sir Claude Hill, Member-in-Charge of the Department of Revenue and Agriculture :—

(1) Mr. E. A. Joseph, I.C.S., Director of Agriculture, Punjab;

(2) Mr. G. S. Henderson, Imperial Agriculturist, Pusa.

In addition to these the Agricultural Adviser to the Government of India will be co-opted on this Sub-Committee and that on Transport as occasion requires.

2. The functions of the Board will be to co-ordinate information and to suggest measures relative to the more efficient exploitation of India's resources in the matter of animal and mechanical transport and to collate information and advise the Government as to the measures calculated to develop the production of food-stuffs, to encourage local consumption of local products, and generally inculcate economy of resources in all directions.

Reviews.

A Handbook of Nature Study and Simple Agricultural Teaching for the Primary Schools of Burma.—By E. THOMPSTONE, B. Sc., Deputy Director of Agriculture, Burma. Pp. xi + 279 with 115 illustrations. (London: Longmans, Green & Co.) Price Rs. 2-8.

WE congratulate Mr. Thompstone on this handbook of nature study and simple agricultural teaching. Designed for the primary schools of Burma, it provides a model which should be easily adaptable for other provinces of India, and the lead having been given, we hope that agricultural officers in other provinces will follow the example set by Mr. Thompstone. The non-existence of suitable text-books is the greatest handicap to the advance of agricultural education in our primary and middle schools. An effort must be made to remove this obstacle, for it is slowly but surely being borne in upon us that, if we are to make any impression on the agriculture of the country, it must be by the spread of general education amongst the agricultural classes, and that to popularize such education it must have an agricultural tinge or bias.

In his preface the author clearly expresses his aims. "This book," he writes, "is intended to be the means of

(a) imparting to both teacher and pupil some knowledge of elementary agriculture and its importance;

(b) opening up to them some understanding of plant and animal life—giving them an insight into some of the fields of study—and of creating in them an interest in the common natural objects around them;

(c) instructing teachers how to give Nature Study lessons in a more life-like manner than that in which 'object lessons' are now given in schools."

The book opens with some very useful advice to teachers, notes on equipment, and some practical suggestions for studies. The main work is divided into sections dealing with plant-life, soils, crops, trees, birds, and insects. The language is simple, and each chapter ends with some practical instructions to teachers, which should considerably lighten the task of imparting knowledge. Finally the book is copiously illustrated.

Mr. Thompstone has given us a text-book which should serve as a useful model and should act as a powerful stimulus to Nature Study in the province of Burma, with particular reference to which it has been written.- [J. M.]

***

The High Price of Sugar and How to Reduce it.—By HAROLD HAMEL SMITH. Pp. 54. (London: Bale, Sons & Danielsson, Ltd., Oxford House, 83-91, Great Titchfield Street, W.) Price 1s. net.

THIS booklet deals with the production within the British Empire, and more especially throughout India and the West Indies, of cane sugar which is a necessary article of food. The author points out that an increase in the production of this commodity can be brought about by fostering the growth of the sugar beet in the United Kingdom, but mainly by increasing the area and productivity of the cane-sugar-bearing lands in the Empire generally. If the British Empire in future is to be—and this war has shown us pretty plainly that she must be—self-supporting as regards her supplies of sugar it is necessary that not only should there be an increase in the area under cane, but also intensive methods must be applied. The actual or possible acreage available in the whole British Empire for this crop is roughly 5½ million acres, and the average output of sugar per acre is barely 1½ tons. Compare this out-turn with that in Java where 4 tons 6 cwt. of white sugar per acre is a normal thing, and then realize what scope there is for improvement in the British Empire. At present the world's shortage of sugar on account of the stoppage of beet sugar from enemy countries is about 2 million

tons. Given that we make it possible to get 2 tons of white sugar from an acre of cane, the $5\frac{1}{2}$ million acres within the whole British Empire should suffice not only to make good this deficiency but also to dominate the sugar market of the world.

The question now arises whether improvements are possible in the existing sugar industry in India with which we are most concerned. It can be said, without fear of contradiction, that if improved methods of cultivation including better manuring are adopted, and the huge losses which now take place in the manufacturing process in this country be cut, the total amount of sugar produced will make India not only free from her dependence on Java and Mauritius but also enable her to export some quantity. While we believe that, with the better varieties of cane being evolved by Dr. Barber at the Cane-breeding Station, Coimbatore, improved cultivation and the employment of less wasteful methods of extraction of juice and its conversion into sugar, there is every hope of establishing a successful sugar industry on a sound basis in India, we differ from the writer in the *Louisiana Planter*, quoted on page 17 of this booklet, that "the future of India lies for the present in the conversion of the sugar industry from the old farm crop with its soft *gur* sugar to a delivery of the necessary millions of tons of sugarcane to great central factories to be turned out there as pure sugars—white and nearly white." To any one acquainted with the local conditions this will at once be written down as impracticable in a large number of cases. India consumes not only white sugar but also *gur*. While we agree that the production of white sugar requires specially to be fostered, and there is plenty of scope for it, we must not lose sight of the existing *gur* industry which is also capable of considerable improvement. The two should in fact continue to exist side by side on account of India's peculiar requirements. Under expert guidance and proper organization they will materially help each other. But we need proper guidance from those best qualified to do so, and India should not allow the present opportunity to slip, as this is the most favourable time to put her house in order. Once it is clearly realized that the differences in the

various provinces in India regarding climate, crushing season, acquisition of land, etc., are very similar to those existing between, say, Louisiana and Cuba and Java, and that each province should pick out its counterpart abroad and religiously scrutinise its methods, then much work and waste of time will be saved and a material advance will accrue. India looks to the Government and the Agricultural Departments to point the way, so that capital may be attracted to this most important industry, and we welcome this publication as directing public attention to the possibility of developing the industry in this country at a time when the circumstances emphasize the necessity of increasing the output of this commodity in the Empire itself, so as to avoid the repetition of a similar experience in future.—[M. W. S.]

***

A Survey of the Madras Dairy Trade.—By A. CARRUTH, Deputy Director of Agriculture, Live Stock, Madras. Department of Agriculture, Madras, Vol. IV, Bulletin No. 73. Printed at the Government Press, Madras. Price As. 8 or 9*d*.

IN Part I of this brochure, Mr. Carruth gives a lucid word-picture of the disgusting conditions under which milk which is sold to the general public in Madras is produced. It is quite evident that the writer found it difficult to restrict himself to ordinary everyday language in describing the state of the Madras cattle yards, and the following expression used in page 2 will convey some idea of the author's view of the conditions as he saw them :—

"One wonders that animals can live under such conditions, and that it is possible for any consumer of milk to escape being stricken by disease."

In Part II the methods of milking and cleansing milk vessels are described, and here also a sorry tale is told, everything being done just as it ought not to be done, and the essentials of common cleanliness entirely lost sight of.

Part III deals with the economic aspect of milk production as practised in Madras, and the author is to be congratulated on the very thorough and businesslike manner in which he has tackled this question. It is notable that in Madras where cows are more in evidence as milk producers than in Bombay, the buffalo proves a more profitable animal than the cow even on the basis of milk production for sale as fresh milk—that is, leaving out of account the extra butter fat contents of the buffalo's milk. The carefully compiled statistics given in this part of the pamphlet prove that the dairy industry in Madras is in a hopeless muddle from the commercial as well as the sanitary standpoint.

In the next chapter dealing with the quality of the milk sold, Mr. Carruth exposes the evils of the common Indian practice of driving the cow from door to door and milking at each customer's residence only that quantity which the purchaser requires. In describing the rounds of one particular cow, he shows that the first customer visited, who of course got the foremilk, was supplied with milk containing 1·8 per cent. of butter fat, whilst the last customer on the same round, who presumably paid the same price as the first, was given milk with 9 per cent. of fat.

The analyses given of milk actually purchased in the bazaar practically all show heavy adulteration, and here again the deplorable state of the industry is illustrated this time in a form which is of immense interest to the general public, as the figures prove the practical impossibility of obtaining pure milk in Madras.

Part V deals with the economic effect of the adulteration practised, and it is somewhat remarkable that even after allowing for the extra revenue from added water, the cow is still an unprofitable milk producer in Madras.

Chapter VI deals with the quantity of milk produced in Madras, and in the following chapter the author touches briefly on the cattle breeding problem in that city.

In the concluding general note the position generally is summarized, and the author does not attempt to solve the problem in detail, as he wisely states that this will require much thinking out.

The publication is perhaps the most concise and practical statement of the position of the dairy industry which has yet been published in India, and although it particularly deals with Madras, unfortunately like conditions exist to a greater or lesser extent in most of our large cities, and a study of the facts published and conclusions drawn will repay any one interested in the milk problem or the dairy industry generally. In the interests of the industry, it is to be hoped that Mr. Carruth will in due course publish the result of his "thinking out" the remedies. As this pamphlet shows, he has thoroughly grasped the present situation, and having correctly diagnosed the disease, he is in the proper position to prescribe the cure.—[Wm. S.]

***

Establishment and Management of the Dairy Farm.—By RAO BAHADUR G. K. KELKAR. Bombay Department of Agriculture Bulletin No. 86 of 1917.

THE title of the pamphlet claims a good deal more than could possibly be condensed into a brochure of this size, and it may therefore be looked upon as hints relative to the establishment and management of a dairy farm in Western India. Throughout the booklet Mr. Kelkar is very brief, and in his attempt to condense the information to be imparted, in some cases omits important factors bearing upon the point he is discussing. Chapter 1 introduces the subject, and in Chapter II points to be considered before starting a dairy farm are discussed. Here Mr. Kelkar is on the right lines in advocating the production of city dairy supplies remote from urban areas where land and fodder are cheaper and where much better sanitary conditions exist, but unfortunately he does not touch on the problem of transit; it is somewhat vague to state that the farm must be situated somewhere near a big city or town. Does he mean within 20 miles or within 300 miles, as, given proper transit facilities, fresh milk, cream, and butter can be produced at either distance and sold fresh daily in any of our big cities.

In the third chapter Professor Kelkar gives some very interesting figures as to average weights, prices and yields of various classes

of dairy cattle known in the Western Presidency. These figures are accurate and may be taken as a sure guide by the prospective dairy farmers. Mr. Kelkar very wisely refrains from mentioning the "so many seers per day" cow which we hear so much about, but gives average yearly returns.

The various points to be noted in selecting the various classes of cattle are carefully described, but here again, Mr. Kelkar is too brief. He dismisses the vital subject of the importance of the sire in the herd with three brief lines. Indian dairymen, if ever they are to do anything to improve the dairy breeds of the country, must realize above all things the importance of breeding only from a first-class sire. A cow only produces, say, 8 calves in a lifetime. A stud bull may sire 300 to 400.

In closing Chapter III, reference is made to crossing Indian cattle with imported sires, and it would have added to the value of this publication if the author had dealt with the advantages and disadvantages of this system from the Indian point of view.

Chapter IV gives a deal of useful information concerning the buildings required on a modern dairy, and a plan is appended showing the lay-out of a dairy farm, giving the relative position of one building to another. It would have been advantageous if a few large-scale sketches showing details of construction, cross-sections of different types of cattle-sheds, etc., had been given. Working drawings could not very easily be prepared from the information provided.

In Chapter V the important subject of feeding is dealt with on sound lines, but the great importance of feeding always a proportion of green fodder to cattle in milk is dismissed with a line. In an appendix (C) referred to in this chapter a scheme for the production of a continuous supply of green fodder for a milking herd is given, and it is surprising in view of latter-day results to find no mention of Rhodes grass in this.

Chapter VI deals with the care of animals, and the ration recommended for calf-rearing seems somewhat meagre. In this chapter it would seem that the author might with advantage have said

something about the very important point of weaning calves at birth and milking the dam without the presence of the calf.

Chapter VII is headed "Milk products," and deals with milk, its production and distribution, cream, butter, *ghi*, and various Indian food preparations made from milk. It is a pity the author does not emphasize the importance of correct cream ripening in connection with butter-making; this is vastly important in India where so much inferior butter is made from over-ripe cream.

Chapter VIII disposes of that all-important subject "Cleanliness in the dairy," and in it the author does not even mention the value and importance of scalding utensils, etc., with live steam.

Chapter IX outlines the establishment necessary for a dairy of a certain size.

Chapter X gives correct and useful information as to records which should be kept, and in the following chapter a complete and useful list is given of the requisite plant, utensils, and furnishings for a dairy of a certain size.

In Chapter XII the author summarizes what he terms the business aspect of the dairy industry, and his figures will be found to be a safe basis for working on in connection with the results to be obtained from a milk-supplying dairy farm in the Deccan.

In the appendices details of the forms recommended for use in keeping records, dimensions of buildings, list of cultivating implements, average yields of various classes of fodder, analyses of feeding stuffs, estimates of plant for a milk-collecting station, and other useful and carefully compiled information is given.

The Bulletin generally is practical and useful, and the pity is that Mr. Kelkar did not give the public the benefit of a little more of his undoubted knowledge of the subject.—[Wm. S.]

***

We have received from the Department of Agriculture, Mysore, a **Bulletin** recently issued **on the Cultivation of Areca Palm** in that State.

It is well known that next to the coconut, areca is economically the most important palm grown in India, almost every part of it being used in one form or another. The tree is practically confined

to India, Burma, and the Malay Peninsula and Archipelago, and from this area the world's demand for areca-nut is supplied. The total area under it in Mysore is nearly 42,500 acres, and the value of the crop is approximately 54 lakhs. The Bulletin gives useful information regarding the cultivation, manuring, and harvesting of the crop as also its diseases and pests. Experiments with a view to improving the quality and quantity of the crop by manuring and selection work are in progress on the Marthur farm, and as the yields vary from 10 maunds in Bangalore to 40 to 50 maunds in the better gardens in Shimoga, there seems plenty of scope for improvement in the crop.

This Bulletin is the first of a series in which it is proposed to discuss the present position and future possibilities of the more important crops of the State. This line of work is most useful, and we commend it to the notice of the Agricultural Departments in British India, for an accurate survey of existing agricultural conditions must precede any improvements of value.—[EDITOR.]

***

The **Mysore Agricultural Calendar for 1918** maintains the standard of its previous issues. Though quite a small publication of 64 pages, it contains a lot of useful information. The opening pages give a list of the full staff of the Department and a brief description of the departmental farms and their work, in which we notice the success of the Department's investigations on *ragi* (*Eleusine coracana*) and sugarcane. Besides monthly notes, there are ten very useful and instructive articles, among which those on the Dairy Herd on the Hebbal Farm and Sericulture in Mysore are of more than local interest. As the Calendar is also issued in vernacular and the price is nominal (only an anna), there is likely to be a good demand for it among the classes for whose benefit it has been issued.—[EDITOR.]

***

Journal of the Indian Economic Society, Vol. I, No. 1, March 1918, Bombay. Annual Subscription Rs. 5.

WE extend a welcome to this quarterly issued by the Indian Economic Society of Bombay. In the editorial foreword the object

of the Journal has been defined as being—(1) to strive to stimulate and focus the energies and thoughts of all those persons who are interested in the promotion of the economic advancement of the Indian people, (2) to discuss from time to time problems concerning the economic development of the country, and (3) to assist in the formation and dissemination of correct views on all economic questions.

In the section of Articles there are papers on (1) The Indian Budget for 1918-19, by Prof. Kale of the Fergusson College, Poona, (2) The Village in the Melting Pot, by Professor Gilbert Slater of Madras, (3) The Organization of Research in India, by Mr. Mazumdar, and (4) Capital and the Rate of Interest after the War, by Mr. M. J. Antia.

Among these the two of particular interest to those connected with the agricultural development of India are the one on the village in the melting pot in which Prof. Gilbert Slater throws some new light on the important question of fragmentation and excessive subdivision of holdings and the other on the organization of research in India by Mr. Mazumdar which is a powerful plea for the promotion and organization of scientific research in this country. We wonder whether Mr. Mazumdar is aware of the existence of the Board of Scientific Advice in India which co-ordinates the work of Government Scientific Departments in India or the Board of Agriculture which does the same work for Agricultural Departments in this country, as we find no reference to them in the article at all.

The next section is devoted to notes on (1) Railway Nationalization, (2) Indian Companies Restriction Act, (3) The Bombay Rent Act, (4) Treasury Bills, (5) Gold Mint, (6) War Finance and Transfer of Funds, and (7) The Bombay Revised Financial Statement. These are followed by a review article on "Mr. Russell and the Reconstruction of Society" which is interesting reading.

The concession granted to *bonâ fide* students in the matter of subscription (Rs. 3 instead of Rs. 5) is substantial and will, we hope, be availed of by students who have taken up Economics as their subject in the University.—[EDITOR.]

We have received from the Grihastha Publishing House of Calcutta a brochure on the **Anatomy of Silkworm and Moth** by Mr. M. N. De, Sericultural Assistant, Agricultural Research Institute, Pusa. It is a booklet of 25 pages in all, with nine text figures. As its name implies, it gives a description of the four stages (egg, larva, pupa, and moth), as also the internal and external organs, of the species *Bombyx mori*. The price is As. 6.— [EDITOR.]

Correspondence.

HANDLING YOUNG STOCK.

To the Editor,

The Agricultural Journal of India.

Sir,

My experience in India is entirely in accord with the view expressed by Mr. R. Cecil Wood in his letter in the current issue of your Journal.[1]

One of the most necessary characteristics in a milch-cow is that of docility, and I have found that in order to rear milking stock with this quality it is essential that the animals should be tied up and fed by hand daily, practically from birth. In the Military Dairy Farms we use different breeds of Indian dairy cattle and find this practice beneficial with all.

Poona :
April 10, 1918.

Yours faithfully,
W. Smith.

DENSITY OF INDIAN COTTON BALES.

To the Editor,

The Agricultural Journal of India.

Sir,

Professor Todd[2] is legally right when he says no mention is made on page 126 of Indian bales. The book is entitled "The World's Cotton Crops" and deals mainly with the economic side.

[1] *The Agricultural Journal of India*, vol. XIII, part II, p. 368.
[2] *loc. cit.*

Any one reading it and trying to form "*impressions*" would certainly think the Egyptian system of baling and pressing is the best in the world. India gets no praise anywhere. I would draw attention, *e.g.*, to page 20 where it is stated that "bad handling of the lint and seed in picking and *afterwards* have degraded Indian cotton to the lowest position in the cotton-growing world." I should not have mentioned this book except for the fact that Professor Todd has been in India since it was written and has lectured on Indian cotton before the Society of Arts, without however drawing any attention to "pressing" and "baling," which is one item at least in which most parts of India are ahead of the rest of the world.

LYALLPUR:
January, 1918.

Yours faithfully,
W. ROBERTS.

THE PROBLEM OF SUGAR MANUFACTURE IN INDIA.

Mr. A. E. Jordan has sent us a further contribution on this subject for publication. His letter and Mr. Wynne Sayer's reply thereto have been held over till October on account of pressure on our space.—[EDITOR.]

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS

The Future of Our Agriculture, by Henry W. Wolff. (London : P. S. King and Son.) Price 12*s*. 6*d*. net.

Manual of Milk Products, by William A. Stocking, Professor of Dairy Industry at Cornell University. Illustrated. (London : Macmillan & Co., Ltd.) Price 10*s*. 6*d*. net.

Late Cabbage from Seed until Harvest : also Seed Raising, by E. N. Reed. Pp. xiii + 131. (New York : J. Wiley & Sons, Inc. ; London : Chapman & Hall, Ltd.) Price 6*s*. net.

Greenhouses : Their Construction and Equipment, by W. J. Wright. Pp. xvi + 269. (New York : Orange Judd Co. ; London : Kegan Paul & Co., Ltd.) Price 1.60 dollars net.

Food and Garden, by H. A. Day. (London : Methuen & Co.)

The Principles and Practice of Pruning, by M. G. Kains. Pp. xxv + 420. (New York : Orange Judd Co.) Price 2 dollars net.

The Scientist's Reference Book and Diary—20th issue for 1918. (Manchester : Messrs. Jas. Wooley, Sons & Co., Ltd.) Price 2*s*. 6*d*.

A Laboratory Manual of Farm Machinery, by F. A. Wirt. Pp. xxii+162. (New York : J. Wiley & Sons, Inc. ; London : Chapman & Hall, Ltd.) Price 6*s*. net.

Liquid Fuels for Internal Combustion Engines, by H. Moore. Pp. xv + 200. (London : Crosby Lockwood & Son.) Price 12*s*. 6*d*. net.

Allen's Commercial Organic Analysis. Fourth Edition, entirely re-written. Vol. IX. Edited by W. A. Davis. With Index for all the Volumes. Pp. xviii+836. (London: J. & A. Churchill.) Price 30*s*. net.

The Chemistry of Farm Practice, by S. E. Keitt. Pp. xii + 253. (New York: J. Wiley & Sons, Ltd., Inc.; London: Chapman & Hall, Ltd.) Price 6*s*. net.

A Course in Food Analysis, by Dr. A. L. Winton. Pp. ix + 252. (New York: J. Wiley & Sons, Inc.; London: Chapman & Hall, Ltd.) Price 7*s*. net.

Principles and Practice of Milk Hygiene, by Professor L. A. Klein. Pp. x+329. (Philadelphia & London: J. B. Lippincott Co.) Price 12*s*. 6*d*. net.

Annual Reports on the Progress of Chemistry for 1917. Issued by the Chemical Society. Vol. XIV. Pp. ix+264. (London: Gurney & Jackson.) Price 4*s*. 6*d*. net.

The Organism as a Whole from a Physico-chemical Viewpoint, by Dr. Jacques Loeb. Pp. x + 379. (New York and London: G. P. Putnam's Sons.) Price 2.50 dollars.

The Wonders of Instinct, by J. H. Fabre. Translated by A. Teixeira de Mattos and B. Miall. Pp. 320. (London: T. Fisher Unwin, Ltd.) Price 10*s*. 6*d*. net.

Insects of Economic Importance: Outlines of Lectures in Economic Entomology, by Glenn W. Herric, Professor of Economic Entomology, Cornell University. (London: Macmillan & Co., Ltd.) Price 5*s*. 6*d*. net.

School Entomology, by E. D. Sanderson and L. M. Peairs. Pp. vii+356. (New York: J. Wiley & Sons, Inc.; London: Chapman & Hall, Ltd.) Price 7*s*. net.

Rustic Sounds and other Studies in Literature and Natural History, by Sir Francis Darwin. (London: John Murray.) Price 6*s*. net.

Secrets of Earth and Sea, by Sir Ray Lankester. (London: Methuen & Co.)

A Text-Book of Mycology and Plant Pathology, by John W. Harshberger, Ph.D., Professor of Botany, University of Pennsylvania. (London: J. & A. Churchill.) Price 15*s*. net.

Soil Biology, by Dr. A. L. Whiting. Pp. ix + 143. (New York: J. Wiley & Sons, Inc.; London: Chapman & Hall, Ltd.) Price 6*s*. net.

Originality: A Popular Study of the Creative Mind, by T. S. Knowlson. Pp. xvi + 304. (London: T. W. Laurie, Ltd.) Price 15*s*. net.

Lectures on the Principles of Symmetry and its Application in all Natural Sciences, by Professor F. M. Jaeger. Pp. xii + 333. (Amsterdam: "Elsevier" Publishing Co.)

The Electron: Its Isolation and Measurement and the Determination of some of its Properties, by Professor R. A. Millikan. (University of Chicago Science Series.) Pp. xii + 268. (Chicago, III: University of Chicago Press; London: Cambridge University Press.) Price 1.50 dollars net.

Veterinary First Aid and Horsemastership in the Service, by Major H. J. Axe, Army Veterinary Corps. Pp. 484. (Allahabad: The Pioneer Press.) Price Rs. 5.

Veterinary Obstetrics, by Professor W. L. Williams, New York State Veterinary College. Pp. xiv + 637. (Ithaca: Published by the Author.) Price 5 dollars.

Strangeways' Veterinary Anatomy, revised and edited by I. Vaughan. Tenth Edition. (Edinburgh: W. Green & Son.) Price £1 4*s*.

Essentials of Veterinary Physiology, by D. Noel Paton. Second Edition, revised and enlarged. (Edinburgh: W. Green & Son.) Price 12*s*. net.

Practical Bacteriology, Microbiology and Serum Therapy (Medical and Veterinary), by A. Besson. Translated and adapted from the Fifth French Edition by H. J. Hutchens. (London: Longmans Green & Co.) Price 37*s*. 6*d*. net.

Clinical Veterinary Medicine and Surgery, by P. J. Cadiot, Professor of Surgery at the Veterinary School of Alfort. Translated, edited and supplemented with 49 new articles and 34 illustrations by Jno. A. W. Dollar, M.R.C.V.S., F.R.S.E. Pp. 619. (London: Gay & Hancock, Ltd.) Price 15*s*. net.

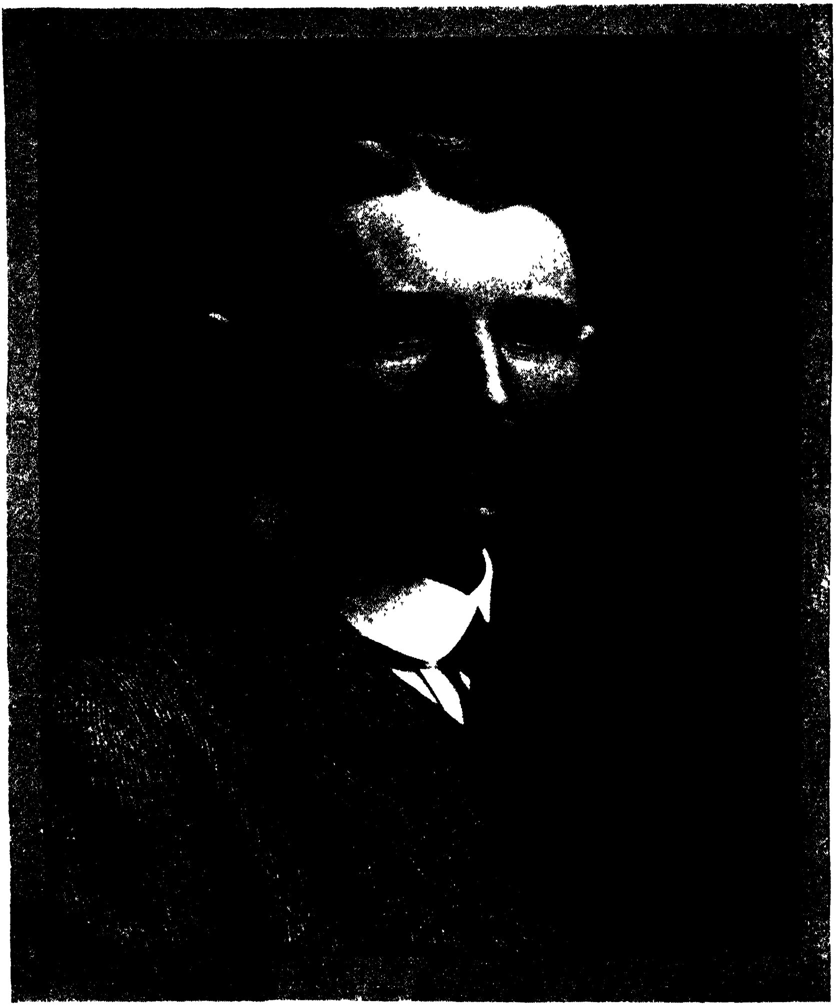
Diseases of Cattle, Sheep, Goats and Swine, by G. Mossu, Professor at the Veterinary College of Alfort and Jno. A. W. Dollar, M.R.C.V.S., F.R.S.E., M.R.I. Pp. 785. Price 25*s*. net.

The Camel and Its Diseases, being Notes for Veterinary Surgeons and Commandants of Camel Corps, by H. E. Cross, M.R.C.V.S., D.V.H., A.Sc. Pp. 148 with 48 illustrations. (London: Baillière, Tindall & Cox.) Price 5*s*. net.

THE following publications have been issued by the Imperial Department of Agriculture since our last issue :—

Special Indian Science Congress Number of the *Agricultural Journal of India*, 1918. Price Rs. 2 or 3*s*.

Some Camel-feeding Experiments, by H. E. Cross, M.R.C.V.S., D.V.H., A.Sc. Price *As*. 2 or 3*d*. (*Pusa Agricultural Research Institute Bulletin No. 77.*)



BERNARD COVENTRY, C.I.E.,
Agricultural Adviser to the Government of India, 1912-1916.

Original Articles.

THE ORGANIZATION OF AGRICULTURAL RESEARCH IN INDIA.

BY

H. M. LEAKE, M.A., F.L.S.,

Economic Botanist to Government and Principal, Agricultural College, Cawnpore.

I

THERE is only one way of approaching problems of organization and that is through a clear appreciation of the object to be achieved. Organization usually assists, but, where it cannot do so, at least it should not retard, the attainment of that object; in other words, organization is merely a means to an end and not an end in itself. That may appear a trite and commonplace statement; nevertheless, in spite of its truth, it is wonderful how frequently we find that it is overlooked and in what a number of cases the real end is lost to view in the organization. There is a second generality, equally true but not, possibly, so self-evident at first sight; it is this: while organization is not, and cannot be, an end in itself, it can, and reasonably may be, an end for personal ambition. There is a third truth, so personal that it probably will never be recognized as such; it is that no man is essential. Man will, for all time, continue to consider that his own line of endeavour, if not he himself, is the essential cog in the work of the world, the cog into which all others must be dovetailed. Organization is an essential cog, but no more than any other line of activity is it the main one in human progress. It is failure to recognize the truth of these generalities and their

interdependence that is responsible for more disappointment, both personal, in stultified careers, and impersonal—if disappointment can be impersonal—in schemes abortive of any achievement, than bears contemplation.

The subject I have set myself to discuss in this article is merely a special case of the generalized problem of the relation of organization to the other factors essential to any scheme of development. In this country research of any sort, and agricultural research in particular, if it is to be accomplished, is likely to remain, for some time to come, one of the functions of Government. The subject narrows itself down, therefore, to a special aspect of that section of the subject in which the organization is represented by Government. It will assist us in our discussion of that special case if we are able to extract from a prior consideration of the main problem any general principles which we can then proceed to apply to our more particular object.

II

The soundness of the deduction drawn from the three generalities just referred to is worth a few minutes' consideration, since, if it be true, in the proof of its truth should lie the means of ascertaining the way in which this expenditure of misdirected energy can be avoided. I am afraid that, to reach the truth, we must penetrate somewhat deeply into a study of human nature and of the motives which actuate the average individual, and combine with this a consideration of the actual conditions under which the individual works and which provide a field for the play of those motives. Let us look at those motives first. It is a statement frequently made that man, in the abstract, is selfish, and it is easy to deny this statement and to point to instances of selflessness in proof of that denial. I think myself, the upholder of the original statement is not free from a confusion of thought and would fail, if asked, to define the meaning of the word selfish. In its literal sense it means a man wrapped up in himself, in its vulgar sense it is limited to the man whose primary consideration is the satisfaction of his own personal worldly desires. The distinction is, perhaps, subtle, but, nevertheless,

pregnant. We can probably all call to mind persons whose lives are spent in "good works," the type who is always collecting subscriptions for desirable—I use the word advisedly and in no sarcastic manner—objects. We will probably refer to him as an unselfish person and with correctness, but in doing so we are using the word in the vulgar sense. The same person may be, in the literal sense of the word, to the last degree selfish. I can call to mind persons so immersed in "good works" that they are unable to take even a passing interest in matters affecting the future of the human race, persons in whom the latest war news raises no trace of interest. It is possible, without questioning the "goodness" of their work and while still holding such persons in high esteem, to maintain that they are in a high degree selfish—wrapped up in self; to use an aphorism, in their very selflessness they are selfish. I think, then, that our original statement, that man is selfish, is generally true in the literal sense—I would go as far as to say he is very selfish— but I have sufficient faith in human nature as a whole to deny the truth of the statement in its vulgar sense. Burns was not lacking in insight into human nature when he prayed the gods to give us the gift to see ourselves with the eyes of others. He might, I think, have gone further and asked that we might be given the converse gift—to see others with the eyes with which we would see ourselves. It is lack of that capacity, which we may sum up as the capacity of placing ourselves in other men's shoes when we come to judge their actions and motives, it is selfishness in its literal sense, which I would place as one of the foundations on which the truth of our deduction is laid.

We have now to examine the other side, the conditions under which men commonly work; and, if I am to make my meaning clear, I must enter into a short digression. Human endeavour may, for my present purpose, be divided into two classes, progressive or constructive and retrogressive or destructive. I am not concerned with the latter, except in as far as it will explain the distinction between two forms of the former class. The incendiary, the house-breaker, are examples of types whose endeavour is destructive and is, therefore, in the interests of general humanity, kept constantly

under restraint. The exercise of such restraint absorbs the activities of a whole army, comprising a large section of the human race, whose endeavours are, therefore, not directly progressive. Nevertheless, in that such endeavour affords a check to retrogression, it is indirectly progressive. It differs from the truly progressive endeavour in that it is wasted—none the less surely wasted because it is necessary waste. Of such a nature are the labours of whole sections of Government, such as the army and law officials, and of the legal profession. And let me say at once, lest I may cause offence where none is intended, that it is possible to admire the individual effort, although it may be set in such channels, with as true an admiration as the truly constructive effort. I would yield to none in my admiration of the soldier fighting at the present moment in Flanders, and I would maintain his endeavour to be of the highest type although I hold it to be truly wasted.

By any one who has studied books of evolution, from the Origin of Species and the Descent of Man onwards, the difficulty which exists in writing of such subjects as the struggle for existence without using expressions implying consciousness on the part of the individual will be appreciated. The same difficulty occurs here. It is difficult, if not impossible, to speak of these two types of constructive endeavour without using words which imply a different plane, yet the transference of that implication to individual endeavour would be unjustified and unjustifiable. The form of endeavour which constitutes the basis of this article, research, is essentially constructive, and if it may sometimes be referred to in terms which appear to indicate that it is on a plane above others, it should be clearly understood that I desire to advance no such claim for it. It is, perhaps, the most purely constructive of any form of endeavour, but to claim that the individual who practises it is, for that reason, in any sense a man apart, is, as I have said, without justification.

We can now return to the point from which we digressed, the conditions under which work is commonly conducted. The average individual is not free from the ordinary rules of life, and his actions are controlled by the necessity of making provision for himself and dependents. The direction of his endeavour is, therefore, usually

restricted by the necessity for such provision. He is not a free agent and has to select the line of his endeavour under the limitations so imposed. The man who is in a position to make a free choice is comparatively rare, and the man who is in a position to develop to the full the results of his constructive endeavour is rarer still. Consider the case of the artisan. Some new development, fraught with vast possibilities to the industry, may be due to his initiative. Yet he has not the means of developing its potentialities, he has to approach his employers to obtain the necessary means. The whip-hand is in this case with the employer, that is, the provider of the organization. Even the man of independent means, if his personal bent takes him to active constructional work, will rarely be in the position to develop the results of his endeavour to the full; his position is but little advanced beyond that of the artisan. Only in the rare case where both ability and means are combined in one person is the organizer not master of the situation. This case is so rare that it may be considered to be the exception that proves the rule and we can discard it from our present consideration.

Let us revert to the original deduction and see how the considerations just reviewed help us to understand its correctness. If what I have said be true it follows that human endeavour, to reach a practical result, requires the combination of two factors usually centred in different individuals: one of these we may term organization, the second, initiative. It is a case of partnership which will develop the fullest results only when carried out under full mutual recognition of the fact. But it is here that our earlier considerations have effect. It is rarely that we find the organizer and the initiator sufficiently selfless, in the sense I have defined, to enter into each other's points of view to the extent necessary to develop that full mutual recognition. Each strives to emphasize the importance of his own contribution to the common stock, and it is that strife that leads to the abortive schemes and stultified careers which I have depicted as the result. Again let me not be misunderstood, I do not complain of that strife, it is the essence of human nature; it is the result, in part, of ambition, and the world would be a poor place if ambition

did not exist. But ambition stultifies itself if it is overweening and placed in a position to force its own demands : and it is frequently in such a position as between the organizer and the initiator for, as we have seen, the organizer has in general the whip-hand.

What, then, is the true relation between these partners—the organizer and the initiator—in constructive endeavour ? What is a fair division of the reward ? To come to a true decision on this matter is probably impossible. We are all of us, in our especial sphere, either one or the other, and, as I have said, probably none of us are sufficiently selfless to form a truly independent judgment. For myself I recognize I am sufficiently human to make the task an impossible one for me to attempt ; I will merely remark that the only proof that the decision reached was a true one would probably be its complete inacceptibility by all parties—an additional reason for refraining from making the attempt. Nevertheless it will be useful to consider briefly the main considerations which would enter into such an attempt. The initiator differs from the organizer in this respect that he possesses an asset he cannot lose, and it is this asset that forms his contribution to the partnership. If the proposal of the artisan proves on trial to be impracticable, he has still his hands and brains to work with and he is at least no worse off than before. The organizer on the other hand will, in such a case, lose all that makes his position as an organizer ; lose, that is, his capacity for carrying on his trade. His material risk is the greater, and his share of the material reward should be proportionately large. Let us sum up our generalizations as far as we have travelled, and see how far they justify the deduction with which we started. We have seen that organization and initiative usually reside apart ; we have also seen that they are complementary and that full achievement is only possible when the two work harmoniously for the common end. The conditions, thus, are such as leave play for the essentially selfish character of human nature to develop an antagonism between the two which may end in personal disillusionment and abortive achievement. As we will see in the next section, economic development has been in the direction of increasing, instead of *reducing, the antagonism.*

III

We have so far spoken of the two classes, of organizer and of initiator, as though they were individualities. This is not always the case, and we must see briefly what is the exact meaning to be given to them. The actual organizer is, of necessity, an individual, but, with the evolution of constructive effort, economic development has been more and more in the direction of dissociating the second function we have ascribed to him, as provider of the means. Starting from complete association we are able to recognize two stages in the process of dissociation.

We may illustrate the case of complete association by the example of a small business developed from individual enterprise. The provider of the means, or capital, is an active participator in the business. In the first instance, this has arisen with a man of initiative who has not the means for the full development of his initiative and who, therefore, takes as partner a man whose capital will, he thinks, supply the additional means required for this development. Here the interests of both the parties are so clearly coincident that the mutual settlement necessary for the best results is not difficult to arrive at. In such cases the organizer and provider of the means rarely oversteps reasonable limits ; by doing so he would too clearly be slaying the goose that laid the golden egg.

The first stage in the dissociation is the limited liability company. The organizer here is the managing director, but the power resulting from the provision of the means has largely passed to the shareholder whose interests he has to keep in the forefront if he is to maintain his position. He is, therefore, compelled to study to obtain the initiative from the employees at the cheapest price possible, and in the success with which he does this are his own prospects bound up. The interests of organization and initiation are here divorced, nevertheless the necessity for maintaining the efficiency of the business, which is dependent on the employees' initiative, prevents matters being carried too far. The connection between the goose and the egg is still sufficiently apparent to prevent a complete divorce between the two being attempted. Some indication of how far this dissociation will result in attempts at such a divorce is given

by the frequency of labour disputes, which are merely the employees' use of their most powerful method of appeal from the personal organizer to the relatively impersonal holder of the power.

The second stage is more complex, and is found in those cases where Government acts as direct employer. Here we must distinguish between the two sections of Government employees, that devoted to the limitation of destructive activities and that directly constructive. In the following remarks reference is only made to the latter. In theory this case does not differ in essence from the last, but in practice the difference is great. The Government official, or administrator, is here the counterpart of the managing agent, while the shareholder is represented by the general tax-paying public; but, in that it is one of the chief functions of Government's constructive policy to undertake schemes which private enterprise, either from their magnitude or from the indirectness of the return, cannot be expected to entertain, the general public has not that same direct financial interest in the result of the enterprise that the dividend gives to the shareholder, nor has the administrator the same direct incentive as the managing agent to develop efficiency. While, therefore, this stage is the direct antithesis of our original starting point, in that the divorce between the interests of the organizer and the initiator is complete, it, in practice, agrees with those conditions in that only two parties are concerned. The difference lies in this, that while it was to the organizer's direct personal advantage to develop efficient initiative, it is now no longer so. The divorce between the goose and the egg is complete. In the absence of any means of testing the quality of the egg it is no longer essential to keep the goose, and a parrot, which has learned to call itself a goose, would serve the purpose equally well, and might prove more amenable.

Power and organization are, thus, reunited in one hand, but under conditions which have removed the restraint previously imposed on its use. Appeal lies, in theory, to the tax-payer but, even in a democratic country, he is too nebulous an individuality to make that appeal practically available. In practice appeal is to the administrator who thus occupies the position of judge and

advocate in his own cause. He possesses one further advantage; we have seen that the organizer's main claim to the larger share of the spoil rests in the fact that he bears the greater portion of the risk. In the case of the managing director this is only partly true since a major portion of the risk is transferred to the shareholder, while in the case of the administrator the risk is entirely removed. There is, on this account, no longer any justification for preferential treatment, the grounds for which must be sought elsewhere. I have not raised this point with any view to setting forth a case for equality of treatment between the administrator and the initiator in the matter of pay, prospects and such like. The above is only one of the arguments which would have to be considered in a question which is entirely outside our present purpose. My present object is to give as accurate a statement as I can of the conditions which obtain in Government service, and those conditions, as far as we have considered them, indicate the position of the administrator to possess all the advantages but none of the restraints which we see have regulated the relations between the organizer and the initiator in the conditions existing in the other stages we have considered; they are, thus, conditions under which the play for the development of the essentially selfish character of human nature is enormously increased.

If this be a true picture, I will be asked why it is that Government obtains the services of men for that class of work involving initiative. The answer is twofold: in the first place, to take the material aspect, Government service offers advantages such as freedom from the fear of loss of employment, regularity of pay, and pension, which have a certain attraction for the average individual; in the second place, I take the very fact that Government does obtain such service as a proof of the limits of this selfishness and as a justification of my faith in human nature as a whole. Nevertheless the first reasons given are ones that appeal to the unambitious, to the man whose chief desire is to live in contented ease. From both points of view no premium is placed on efficiency, and I, for one, hold it true that Government agency can never attain the efficiency of private enterprise.

That appears to me to be the inevitable conclusion to which our discussion has led us, and, disquieting though it may be and coming as it may in the nature of a shock to some of us, nothing will be gained by ignoring it ; in fact it is only by its full recognition and by acceptance of the consequences involved that we shall be in a position to discover how its effects are to be minimized and the best results obtained.

IV

We are now in a position to approach our main subject and to see how, in the light of this discussion, the conditions offered by Government service affect that particular form of initiative to which the name of research has been given. I have already had the temerity to refer to research as the most purely constructive form of human endeavour. As read with its context, that statement requires no justification but it may require explanation. The essential features will be brought out by a rough comparison between the work of the person engaged in research and that of the artisan. The latter produces something tangible, something which satisfies some of the needs or desires of man, something which is perishable. The result of the work of the former is an increase of general knowledge, an extension of our knowledge into the realms of the unknown ; and to this extent the result is imperishable. That is the broad distinction, but between the two lies a large field of endeavour which belongs entirely neither to one class nor the other, a field of research definitely undertaken with a view to the attainment of some practical end. A very large proportion of the research work, and especially of that undertaken on behalf of Government, is of that nature. The distinction between these two classes of research which, for brevity, we may term pure and applied, is largely a matter of degree but is important. It is, for instance, the difference between the pure study of protozoology, the object of which is to trace the forms and habits of the simplest group of organisms and to obtain a balanced impression of the group as a unit, and the applied, which gives no such balanced impression but concentrates on those forms having a pathological interest and endeavours to work out in

particular those points of the history which appear to offer the greatest prospect for the successful application of preventive or remedial measures. This is a difference of degree rather than principle, for, until a sufficiently detailed survey of the field of work has been made, it is impossible to concentrate with any degree of assurance on the particular spot which offers the best chance of obtaining a practical result in the required direction. Research work of the latter class must commence as a piece of pure research but, while in the former the aim is less definite, in the latter the aim is kept constantly in view and the field of work narrowed down as each side-path is found to be a no thoroughfare. The difference between the two classes of research is thus minor, and the conditions required for the development of both are the same.

From what I have said of the character of research a further important characteristic which distinguishes it from other classes of endeavour, becomes apparent. The engineer is in a position to build a bridge; he can design it to fulfil a particular purpose, to carry rail or road traffic, and he can, to a close degree of accuracy, forecast the cost. All this he is able to do before a stone is cut or a sod of earth turned. In the same manner the cabinet-maker can produce any desired form of chair. The bridge or the chair are produced in accordance with the preconceived design, and the engineer or cabinet-maker can be judged by the results. If the bridge is washed away by the first flood or if the chair breaks the first time it is sat upon, the engineer or the cabinet-maker can be pronounced inefficient. With research this is not so. It is never possible to set out to attain a definite object with the same certainty of success that the engineer can call up. Further, it is rarely that the results prove a negative and show that the object of the research is unobtainable. By their results we cannot know them, for the simple test of achievement—success—fails, and there is no other test of the efficiency which the inexpert can apply.

There is one more characteristic to which I must refer before leaving this question of research. As with the architect and the painter, there is an individuality running through the work of each, which can be detected by the judge in such matters. Two artists

may set out with the intention of recording the same subject; the result may be the same, in that it is a perfect representation of the subject chosen, but, in treatment and in every character by which a picture may be described, the two may be entirely different; nor could the one artist produce, if he tried, the picture of the other. So it is with research. The same practical end may be obtained by two entirely different methods, each method characteristic of the particular individual.

From the above considerations of the general characteristics of research several inferences can be drawn which have a direct bearing on its relation to organization. As a general rule research cannot be a commercial proposition. It is, as we have seen, impossible to guarantee any result, and its employment is, therefore, in the nature of a speculation. Let us, however, be quite clear what we mean in making this statement. It is a lottery, but one in which the prizes are, in the material sense, enormous and, in value, far in excess of the total money put in. It is only necessary to think of the material progress made by civilization in recent years and to trace each item to its basis of research to see that this is so. It is, however, a lottery in which there are a number of blanks. The laws of chance apply, and it is only by taking a large number of tickets that a reasonable chance will be obtained of securing prizes of a value which will give a commercial return on the money. Failure to appreciate this fact, resulting in attempts to test the value of research by taking a sample, as one would purchase and test a sample tin of jam before placing an order for the year's supply, is responsible for a great deal of the discredit in which research is commercially held. The fact is, as I have stated, research only becomes a commercial proposition when carried out on a sufficiently large scale. It is a fact long since recognized in Germany, and it is this recognition which is largely accountable for her industrial efficiency.

In India commercial development has hardly reached a stage when research can be generally undertaken as a commercial proposition, the capacity for purchasing the necessary number of tickets is not yet existent. That capacity is possessed by Government

only, and for some time to come the bulk of research must be carried out under Government auspices, though signs are apparent that the alternative method, that under which so large a portion of the research in England and America has been undertaken, I refer to endowments, will gradually be adopted. In one respect the conditions of development under Government appear to be well suited to the purpose. We have seen that the direct personal incentive towards a demand for "practical" results, that is, results which would form the basis of a commercial enterprise, is present in the least insistent form. On the other hand we have seen that the conditions are such as to concentrate attention on the administrative aspect of every problem, to assume that if the administrative side is arranged for, all will be well. But if I have portrayed the chief features of research aright, it follows that the essential condition for successful research is freedom, freedom to select the line of work to suit the individual temperament and freedom to develop that line of work in accordance with individual dictates.

This, I think, will disclose the first point of weakness inherent in Government employment of research. It is a failure to appreciate that research is essentially individualistic and that the men who undertake it are not and cannot be standardized. Standardization is the essence of army training, still more so, probably, of naval training, and to a less degree of administrative training, but this is not the case with research. The choice has to be made between selection of a man and leaving him to develop that line for which his individuality best suits him, and selection of one whose special leanings appear to render him most likely to succeed in the particular investigation. Which method is the best to be adopted will depend on the particular circumstances. Too often, however, this distinction is not made, and appointments are made for a particular purpose but the man is selected without relation to any special aptitude for the class of work involved; to use a simile I have used before, a goose is required to lay a golden egg but a parrot is selected for the purpose, the fact that both are birds being considered to constitute a sufficient degree of similarity. I do not wish to imply that selection is free from all difficulty—all geese do not lay golden eggs and

it is conceivably possible to select one whose eggs are subsequently found to consist of normal yolk and white. Nevertheless it should be possible to avoid the selection of a parrot, and steps with that end in view would be more readily taken were it not for the fact, which we have already hinted, that, if the parrot proves on acquisition tractable, it is not difficult under the circumstances to foster the belief that it is a genuine goose.

Research, as we have seen, is highly individualistic, and the greater the freedom provided for its development the greater is the prospect of material results. In these circumstances especially, organization, like fire, is a very good servant but a bad master. The limits of its legitimate sphere are to provide a general outline of the problem to be attacked—that is legitimate, for he that pays the piper has always the right to call the tune, and difficulty only arises when the piper is expected to play the violin—and to provide the facilities required for the work and the opening for the development of the results obtained. The very conditions of Government activity lead to the negation of such freedom. The administrative function tends to extend beyond its legitimate sphere, in the direction of defining the problems in too great a detail, and prominence is given to the purely administrative sphere, in that complex schemes are drawn up for the development of the results before these are obtained. This phenomenon is merely administration unconsciously attempting to justify its own existence.

V

Any scheme for the employment and development of research must, therefore, have regard to the essential requirements both of the research and of the administrative aspects, and undue prominence must not be given to those of either. From the administrative point of view provision is required for—

(1) the direction of the work into certain channels while avoiding any too minute a definition of these;

(2) the provision of the means to obtain the best practical developments from the results obtained.

From the research point of view it is necessary to take into account and provide for—

(3) the selection of investigators with a view to the particular work required;

(4) freedom for development of initiative along the lines of individual leaning.

Realization of the first two items demands a channel between the research officer and the executive side of Government, which alone is the authority, indirectly if not directly, to call the tune and to provide the necessary funds for the work and for such developments as arise from it. That channel should be such that the double stream of communication, of explanation as to the nature of the work desired and the problems to be investigated, and of information as to the work done, may be easy, and, what is, perhaps, more important, free from contamination.

That, however, is administrative work of the truly productive kind, and it must not be forgotten that any department, however small, involves a certain amount of administrative work, of the constructive kind to which we have given the name necessary waste, and full organization requires that provision shall be made for this without interfering with the efficiency of the purely constructive section. This is the crux of all such administrative problems and the point where lies the chief danger of the selfish basis of human nature asserting itself. All departments must work through a head, who represents that department in the dealings with Government, and it is the function of that head to deal with both forms of administrative problems. I am not going to enter into the vexed question as to whether that head should be selected from the administration external to the department or from the professional departmental staff. The subject is one which is apt to lead to heated discussion which is far from my present object and would probably obscure the clear recognition which is essential to my subject. I think, however, an unbiassed mind will accept the truth of the statement that the selection of a chief from the departmental staff will lead to the emphasis of the purely constructional aspect of administration, while a selection from outside will swing the pendulum in

the direction of emphasizing necessary waste. The best organization will be one that recognizes and provides for such a tendency in the head, for, if my conclusion is sound, a truly unbiassed head is not procurable.

I have here used the word head, instead of the more commonly adopted one of director, advisedly, because I think that the meaning contained in the latter term contains the germ of the misunderstanding so common on the present subject, and its use consequently masks the true function of the post. A director should naturally direct, but can he direct in a subject in which he is deficient in technical knowledge? Is not his correct duty rather to assist the members of the professional staff by freeing them from the routine administrative duties, and by acting as intermediary between these and Government? Is not this the position of a secretary rather than of a director? Consider the case of Government seeking technical advice on some matter. It applies to the director who bases his reply on the opinions of his professional staff. That reply is accepted by Government as the considered reply of their professional advisers; but is it? Let us look at the matter more closely. The director, on receipt of the enquiry, has to draft a reply; in doing so he asks the opinion of that member of his staff who is best acquainted with the matter in hand, and on his opinion drafts his reply. Now there are several features that require noting in this procedure. In the first place, there is no real reason why he should consult his staff if he does not care to do so; in the second place, the decision as to which of his staff should be consulted rests with him; in the third place, the expression of that opinion remains in his hands and there is consequently room for misrepresentation; fourthly, should he differ from his staff, in his reply he may ignore their opinion and merely put forward his own; and, lastly, those who were consulted by him may be left in ignorance of the exact reply and of whether their views were represented. I do not say that this is what happens, but this is what may happen, and while it remains possible it cannot be said that Government are using professional advice for they cannot, in any particular case, be sure they are getting it.

These objections are, perhaps, more weighty when the head is taken from the general administration, but they are by no means removed when the head is taken from the professional departmental staff. In few cases, and only in the smallest research departments, is the head as fully qualified as the members of his staff to express an opinion on all subjects submitted for opinion ; in many cases the matter will be one which one of these will have made the subject of special study. In any case, therefore, organization should aim at removing these drawbacks.

It is an unprofitable task setting out on destructive criticism unless it can be followed by constructive proposals, and it is only because, I think, that the difficulties raised can be overcome that I have ventured to discuss the question. They would be overcome if the head were to deal with the references from Government which require professional opinion for reply by means of committees of himself and those members of his staff concerned with the matter ; in these the subject could be discussed, the form of reply agreed on, and in any case of an important difference of opinion, a note of the difference included in the report. The danger of the proposal is, by over-organization, the end would be lost in the means and the remedy become worse than the disease. The establishment of formal committees is, therefore, to be deprecated, nor is it desirable that the committee should take the responsibility for the details of the reply ; informal meetings, as found needful, of those concerned is all that is necessary, while the issue of a copy of the reply ultimately sent to Government to all members of the committee would ensure that misrepresentations have not been made, and give sufficient publicity to ensure that the right men had been consulted.

The procedure here advocated involves details of organization only, and yet would go far to meet the objections we have raised. It has been customary for discussion to centre on the relative advantage of an administrative external, or a professional departmental, head. The discussion tends, as I have said, to be heated, but the truth is, I think, that with a suitable organization, and one such as I have outlined is I think suitable, the point is relatively a minor one. It is frequently said that experts are unable to agree among

themselves and that a departmental head proves a failure. That, I am inclined to think, is frequently true, but I am inclined to think that this, if it be true, is the result of the system and not an inherent character of scientific and professional men as it is so often considered to be. No man really imbued with the spirit of research cares to give up that work for administration, and the lack of agreement commonly laid at the door of scientific persons is largely due to the fear that the man lacking in the true spirit of research will, attracted by the material prospects, endeavour to obtain the post of head, and to the belief, probably not ill-founded, that the conditions are such as to make that endeavour successful and that interference from such an one would be less easily met than interference from one having no claim to professional knowledge. The organization of that system to ensure that acceptability by his colleagues is at least taken into consideration in the selection of a head, combined with a popularizing of the idea that the higher emoluments are as compensation for the loss of time from his own particular work involved in the doing, if I may so express it, the dirty work of the department, would go far to remove this slur on the character of scientific men.

VI

What we term agricultural research is mainly, if not entirely, applied, and differs in no essential from other forms. In practice, however, there are certain features which necessitate special provision. Agriculture, as a practice, in India especially, is mainly the successful handling of the plant in relation to soil and climate. Now climate and, perhaps to a less extent, soil are purely local conditions, and it follows that a very large proportion of the problems which form the basis of agricultural research deal with that interrelation and, consequently, require a local knowledge. Thus, though it might not perhaps be impossible to breed an improved type of cotton for the Bombay cotton tracts by work in Cawnpore, it would be putting unnecessary difficulties in the way of the work which could be undertaken with a much greater chance of success

in that Presidency itself. Again, not infrequently, the local conditions themselves form the subject-matter of investigation, as in a study of the soil in its relation to moisture.

That is one special feature of this class of research. Another is that, in this probably more than in any other class, do the lines of investigation cut across the commonly accepted divisions of science. I will explain what I mean by a concrete example. Consider for a moment the question of plant disease. It may be caused by a fungus or insect, in which case we are concerned to work out the life-history, concerned, that is, with the particular branch of botany known as mycology or that of zoology known as entomology. Having obtained the knowledge which these studies yield, we have now to think of a remedy. These studies will have shed light on the most vulnerable point in the life-history of the organism, but we must not forget that such disease is the result of the reaction of two organisms; that frequently the best method of preventing such attack is by attempts, not to destroy the parasite, but to increase the resistance of the host. Now the resistance of the host is largely a question of health, and we are thus brought into direct contact with physiological problems, the relation of the plant to its surroundings, and, through this, with the chemical or physical aspect of the soil. In this way it is not merely conceivable, it is demonstrable, for actual examples could be quoted, that a chemical or physical control of the soil conditions may provide the desired immunity of the crop-host to the attacks of the parasitic organism. In this feature agricultural research is only rivalled by medical research taken in its widest sense; and the conclusion to be drawn from it is that in agriculture, probably more than in any other subject, do problems arise which involve combined attack from more than one direction. Such a combined attack involves co-operation, and every effort to develop such co-operation should therefore be made. The desirability for such co-operation is, I think, recognized, and much has been written and said about such. Co-operation is essentially a growth from within by consent of the concerned parties; it cannot, from its very nature, be the result of an external graft. This is recognized in the case of the co-operative movement in which great care is taken to prevent

any trace of external influence creeping in, and yet between individuals co-operation is expected to develop from mere chance association. From its very nature official provision cannot be made for co-operation, and the most that can be done is to avoid conditions inimical to its development.

These are the special features, additional to those already discussed, which have to be taken into consideration when the organization of such research is in question. They merely emphasize certain aspects of the more general case that we have already discussed and raise no new considerations; the organization we have already outlined for the more general case should, therefore, be adaptable to the special conditions here found.

VII

For some little time past rumours have been rife of a scheme for the departmentalization of research in India along the lines of the commonly recognized divisions of science. Thus the proposal appears to involve a disbandment of the present organizations for research, and the establishment of independent departments of chemistry, botany and the like, and it involves thus a considerable and violent break-away from the present lines of development. Though no very definite particulars of the scheme have so far seen the light, sufficient information is perhaps available to admit of its discussion in the light of the above review.

The advantages which appear to be claimed for the proposal are somewhat as follows :—

(1) The association into one service of all men engaged in work on the same branch of science will give rise to an *esprit de corps* which is at present lacking between the scientific workers in India.

(2) That *esprit de corps* will have practical vent in the establishment of a journal for the publication of research in each particular branch of science, the circulation of which will lead to reciprocation with foreign bodies and an exchange of publications, and that a library containing an amount of literature far in excess of any that could

be purchased and much that could not be purchased, would be built up.

(3) The establishment of a strong body of research workers in each subject out here would make it possible to recruit men at a younger age who would be moulded in the plan of a service under the guidance of senior men.

(4) The effect of (3) will be to cheapen the service.

Let us look into each of these claims in turn and see how far they stand the light of criticism.

True *esprit de corps* is a complex phenomenon. It includes that community of spirit which draws together members of the same college or school, when unknown to each other, wherever they meet; that is an *esprit de corps* based on past association with which we have no concern at present. It also includes that spirit which leads one member of a service to uphold another because he is a member of that service. Such *esprit de corps* is, on many grounds, desirable but, in so far as it leads to the acclamation of work on *a priori* grounds because it is the work of a member of the service, it is an unscientific spirit and, therefore, undesirable—in fact this form of *esprit de corps* is not entirely compatible with a scientific spirit.

If *esprit de corps*, in its full sense, is not desirable, it does not follow that that mutual confidence and mutual knowledge of other workers, their aims and ideas, such as arises out of personal acquaintance and as forms one aspect of *esprit de corps*, is also undesirable. We may admit that the proposed scheme will develop this, but the question is whether there are not attendant disadvantages which outweigh the advantages, and whether the same advantages are not obtainable by means which avoid the disadvantages.

We may consider a practical example; such mutual knowledge as we are contemplating implies something more than the knowledge given by infrequent intercourse; it implies living and working together; it implies a central headquarters station at which the members of the service spend a considerable portion of their time and which they look upon as their home. In certain cases, the location of the headquarters station would have to be determined

by the needs of the work which will not necessarily be coincident with the needs for the healthy mental, as well as physical, condition of the workers. In the past too little consideration has been given to the fact that scientific men are human beings and require, like other persons, diversion, and that it does not do to isolate them where such diversion is not obtainable. A wife is probably the only person with whom a man could live in constant association unrelieved by outside visitors; many persons will probably maintain that that is not possible, and it is, therefore, somewhat extraordinary that scientific men should be expected to do so.

We may consider, for instance, the application of these facts to a botanical service. Such a service must include a plant-breeding section, and the choice of a headquarters station would thus be limited by considerations as to availability of land, suitability of climate, etc. Those limitations would most certainly lead to its establishment at some distance from a city, involving isolation and lack of diversion, and we have to choose between conditions unsuitable for the work or unsuitable for the workers.

One of the special features of agricultural work has been stated to be the local nature of the problems, that, for example, it was not possible to carry out in the United Provinces with any hope of success work which had as its object the development of a cotton suitable for Bombay. Under the scheme under consideration the investigation of such problems would be, presumably, by a member of the service deputed to make the study in the locality. In the subjects involving plant-breeding it is no exaggeration to say that it may be a matter of ten years before practical results begin to develop. If, therefore, the investigation is to be personally conducted and not merely to consist of a general supervision of subordinates, residence away from headquarters for the greater portion of his service becomes the lot of such an investigator, and it is difficult to see in what way he benefits from his attachment to a centralized service. The centralization will be either a dead letter or will involve interference by a chief ignorant of the local conditions, an interference which would be the very negation of that freedom we have seen to be essential.

Such a centralization of departmentalized research appears to me totally unsuited to meet the needs of a large section of agricultural research. Its suitability to other needs such as technological research is another matter; the major portion of such work is not concerned with local conditions, and it is possible that material could be collected on relatively short tours and the results worked out at a central institute; the same possibly applies to the systematic work of a botanical survey, and to geological work, which latter alone is at present dealt with by a centralized organization such as we are discussing. On this point I venture no opinion, but if the scheme is to be universally adopted, it must make adequate provision for the whole and not for a part only, and it seems to me to fail because it is totally unsuited for the development of agricultural research.

The advantages claimed under the third and fourth heads constitute an appeal to the administrative side of Government, which of necessity has to scrutinize very carefully the financial side of all proposals and must have an *a priori* leaning to any scheme for which economy is claimed. There is, however, an old adage which has reference to cheap goods being nasty, and, under conditions which prohibit any clear appreciation of the true value of the goods, and these are the conditions we have shown must hold in the employment of research by Government, there is considerable danger of their nastiness being overlooked. The claim, therefore, requires careful consideration.

It contains as a basal assumption that it is possible to pick out a research officer before he has developed the research habit. This is either the endowment of the nominating board with a gift of prophecy, or it is the assertion that all men who attain a certain standard of education will develop the faculty for research if placed under suitable conditions. The first alternative we may discard; of the second, I would question, and be tempted even to deny, the truth. To those who maintain this, I would suggest that they trace the careers of, say, those men who have taken a first class in the Natural Science Tripos or in any similar examination. I think they will be surprised to find how small is the proportion of these

men who proceed far with research. In truth the choice lies between two alternatives, either recruitment must be at an age when the capacity for undertaking research has been developed, and that development must form part of the qualification, or it must be recognized that there will be a large proportion of unsuitable men and that the organization must arrange for their elimination or for their diversion to more congenial employment. It may be true that a certain cheapening of the service will result if the measure of the cheapness is taken as the initial pay, but when allowance is made for the wastage due to the elimination of unsuitable material, the result will not be, I think, in favour of early selection.

I do not here propose or desire to enter here into educational questions, but if education in India is to develop in the way it must, if our aims in the country are to be fulfilled, it will have to include the development of the research faculty in the Indian. Few Indians have hitherto developed that faculty—not, I believe, because it is foreign to their nature, but because of the lack of opportunity. We have stated above that to have reached a certain educational standard does not necessarily imply the possession of a faculty for research, but we may add that a latent faculty of research does not develop *per se*. Its development is largely the result of association, of atmosphere, the atmosphere that is only created by a master in research. If, then, Indians are to take their place in research, it is necessary to create the atmosphere, and consequently, as time goes on, the need will be for a higher and even higher standard in research. It is hardly necessary to ask the question whether the method of recruitment involved in the scheme is likely to lead to this result.

I have left the question of literature to the last because it is to some extent bound up in the previous discussion. The desirability of establishing a library, of making it as rich as possible, and the advantage of having a means of obtaining by exchange are too obvious to need discussion. With the publicity given by exchange arises the necessity of maintaining a standard; but the difficulty of maintaining a standard, even of obtaining a correct valuation of standard in particular cases, and the tendency to sacrifice it when the contributors form a small body, must not be overlooked. It is

perfectly true that publication in the home journals has its disadvantages; subjects of investigation are frequently so specialized that home publication committees have sometimes difficulty in assessing the value of particular work; nevertheless, until a larger body of research workers ensures a larger volume of work, and a wider basis for the nomination of a publication committee, home publication is still desirable, especially in the case of younger men. Such publication will impart a sense of assurance and remove any fear of partiality which judgment within the service is bound to create. If I have made my meaning plain it is not against departmental publication, but against enforced departmental publication, that I would make a stand, and, as I have understood the scheme we are discussing, such enforcement constitutes one of its essential features.

VIII

In the above notes I have attempted to draw out the essentials for research and the dangers that lie in the way of their development under the conditions that obtain in Government service. If my argument is sound it would appear that the surest progress lies in the direction of evolution from the present system and not in any scheme of a cataclysmic nature such as that we have last considered. Sound evolution requires, however, a clear appreciation of what it is essential to provide and what to avoid. The present article will have served its purpose if it does no more than help to a truer appreciation of these essentials and so paves the way for a proportioned organization, giving the fullest scope for the development of those forms of constructive endeavour summed up in the word research.

THE OIL ENGINE AND ITS APPLICATION TO INDIAN AGRICULTURE

BY

W. M. SCHUTTE, A. M. I. MECH. E., M. R. A. S. E.,

Agricultural Engineer to the Government of Bombay.

ACCORDING to John Morley, "Evolution is not a force, but a process; not a cause, but a law." The same words apply with equal truth to progress and development. But, after all, it is largely left to the human factor to put both the process and the law into operation, and any new agency which has set itself such a task is to be welcomed as an asset especially if its fortunes are linked up with Indian agriculture.

It seems strange to say that an ancient industry like agriculture is only now coming into the prominence that its importance warrants. Yet it is irrefutably true. For decades, if not centuries, farming has been regarded by the man in the street as an occupation which more fittingly belonged to bygone days; interesting, and crammed with natural incidents perhaps, but not representing the new world—the busy, bustling, throbbing world of achievement and progress.

Many people and some Governments have reflected this opinion, but a corrective has been administered and the national perspective is being adjusted; and this actually applies to India. When entering the district in India for the first time and seeing the method of pumping by means of the country mhote, I naturally thought that in the face of such primitive local methods the success of the internal combustion engine was extremely doubtful. It was not so much the going down the ramp that seemed so ridiculous, as when the bullocks walked backwards up the ramp on the return journey.

Notwithstanding this crude appliance, however, the modern internal combustion engine has come to stay, and it is a circumstance wholly agreeable to this branch of engineering that genuine enquiries are being made, and as a result many power plants are being installed, the motive power of which is the oil engine.

That mechanical power in connection with agriculture is more than ever needed is becoming increasingly apparent. For the sake of comparison I append two tables produced as the result of my own investigation in Bombay Presidency :—

TABLE I.

Irrigation by mhotes.

Index letter	Name of district	Average lift in feet	Number of acres irrigated	Nature of crops	Number of mhotes	Number of bullocks	Annual expenses per acre per annum Rs.	A.	P.
A	Dharwar	45	2	Sugar-cane.	1	4	312	0	0
B	Belgaum	30	2	,,	1	2	127	8	0
C	Jalgaon ..	37	2	,,	1	2	140	0	0
D	Satara	36	2	,,	1	2	250	0	0
E	Sholapur	40	2	,,	1	4	107	0	0

TABLE II.

Irrigation by centrifugal pumps.

Index letter	Name of district	Average lift in feet	Number of acres irrigated	Nature of crops	B. H. P. of engine	Size of pump	Annual expenses per acre per annum Rs.	A.	P.
A	Dharwar	45	15	Sugar-cane	6½	2½″	84	6	6
B	Belgaum	30	20	,,	6½	3″	59	4	9
C	Jalgaon	37	15	,,	6½	2½″	84	9	7
D	Satara ..	36	20	,,	10	3″	100	12	9 *
E	Sholapur	40	20	,,	8	3″	75	11	3

* In this plant, two pumps are taken into consideration owing to very great difference in the lowest and highest water levels.

It will be seen from these tables how much more easily the work done by the bullocks can be accomplished by the oil engine and pump.

There appears to be a great difference of opinion, however, as to which type and make of engine is the best or more suited to agricultural purposes. This applies chiefly to the non-technical class of users.

Those who have had no experience of oil engines seem to have a feeling that they are much more difficult to manage and not nearly so reliable as steam engines.

There is perhaps something to be said for this view, since an oil engine can be more easily put out of adjustment by a careless driver and, unless properly lubricated and cleaned, will undoubtedly give trouble.

A steam engine, on the other hand, has less parts which can be tampered with, and, even when somewhat out of adjustment, will still work, though very inefficiently, as long as steam is supplied to it.

The oil engine, which has to generate its power within itself, will not so easily work at very low efficiency. This, however, is in one way an advantage to the oil engine. It should be the object of every user of an engine to keep it in good working order and running at the best possible efficiency, and to do this requires only a little care and intelligence.

To prove what I say it is only necessary to relate a case in my own department : an Indian boy of 15 years of age came to the College Workshops to learn this particular work, and within a month was able to drive an oil engine and centrifugal pump quite easily ; as a matter of fact he is at present driving a small plant in the district, and I have absolutely no trouble with him as he seems to be thoroughly master of the job. It might be thought that this is an isolated case—not by any means ; there are at least half a dozen boys able to run these engines quite well, all of whom are working under me, the only difference being that they are not quite so smart as the particular one mentioned.

Moreover, quite a number of cultivators have been trained to do similar work ; in most cases looking after their own plants. To use the words of one of these men (a pleader, by the way, who not only understands his own plant but finds it much more economical than pumping by mhotes), " I can say that to irrigate one acre of sugarcane crop I require one rupee or thereabouts, whereas not less than Rs. 4 will be required if the same area is irrigated by mhotes, that is the conclusion I have come to."

To arrive at a true comparison, however, definite units must be used, and the conditions as regards crops, soil, time taken to pump, depth, etc., must also be the same in either case. It is therefore necessary to fix up certain definite conditions which, as near as possible, form an average example.

Accordingly, the comparative Tables III and IV that follow have been based on the following conditions existing in the Punjab :—

(1) Twelve working hours per day.
(2) Thirty days per month.
(3) Total head against which to pump, 20 feet.
(4) Capacity of Persian wheel and of double mhote, each requiring 2 pairs of bullocks, each 1,600 gallons per hour.
(5) Centrifugal pumps of 3 in. size used, capacity 11,100 gallons per hour = 185 gallons per minute.
(6) Working life of bullock, 10 years.
(7) Working life of engine and centrifugal pump, 15 years.

TABLE III.

Bullock-worked mhotes and Persian wheels.

	Per month Rs.	A.	P.
Upkeep of 2 pairs of bullocks	45	0	
Upkeep and repairs of mhote or Persian wheel	5	0	0
Labour—2 men at Rs. 12-8-0 each	25	0	0
Depreciation at 10 per cent. per annum on total cost of Rs. 560 ...	4	12	0
Interest at 5 per cent. on Rs. 560	2	6	0
Total for 1,600 gallons per hour	82	2	0

This is equal to a rate of Rs. 51-4-0 per month, per 1,000 gallons per hour.

TABLE IV.

3 in. centrifugal pump and 4 B.H.P. kerosine oil engine.

(*Note.* Actual average power required is 3 B.H.P.)

	Per month Rs.	A.	P.
* Kerosine oil, 120 gallons at 0-10-0 per gallon	75	0	0
Lubricating oil, 7 gallons at 2-8-0 per gallon	17	8	0
Labour, 1 man	25	0	0
Depreciation at 7½ per cent. per annum on cost of Rs. 1,200	7	8	0
Repairs and renewals at 5% per annum	5	0	0
Interest on capital at 5% per annum	5	0	0
Total cost for 11,100 gallons per hour	135	0	0

Which is equal to a rate of Rs. 12-3-0 per month, per 1,000 gallons per hour.

This is less than one-fourth the cost of pumping by bullocks.

The principal items which go to make up the cost of running these power plants are :—

(1) The cost and nature of the fuel used in the engine ;
(2) the cost of stores including oil, waste, and belting ;
(3) the cost of labour employed to run the machinery ;
(4) the cost of repairs to keep the plant in order ; and
(5) the charges on account of interest on the capital expended.

So it is obvious that when this class of machinery is about to be purchased, there are many more points to be considered than at first appear to be necessary, but to ensure success it only rests with the prospective owner to see that the plant is in the first place suitably designed for the work on hand and secondly to master the details of driving himself ; he will then have little difficulty with the plant.

Sufficient, however, has been said to prove that the power pumping plant, when an oil engine is the prime mover, can be run much more economically than bullock-driven plants, and perhaps it will be advisable to ascertain as to what other branch of agriculture it is applicable. One of the next in importance to pumping is sugarcane crushing, and in this connection recent tests have been carried out at the Government Farm, Manjri, near Poona, which

* Pre-war rate.

have proved conclusively that even the small power plant is a great improvement on the country-made bullock mill.

A mill capable of dealing with 25 acres per season (this being the smallest size made) was imported from America and set to work last year at the Government Farm, Manjri ; the result being that at least 6 per cent. increase in extraction was obtained over the country bullock mill, which means a saving of Rs. 40 per acre per annum, or in 5 years sufficient to buy the whole plant. Of course, there are other advantages such as speed, and being able to crush the cane just when it is ready, and all these are the direct results of the introduction of the oil engine to propel the mill. Then there are other uses to which the oil engine can be employed, such as mechanical cultivation, mechanical traction, ginning, oil extracting, chaff cutting, milling, rice hulling, and baling, and tests are being carried out to determine the saving, if any possible, when the oil engine is employed for this particular class of work.

I have seen quite a number of small businesses in the Presidency where oil engine, oil and flour mill, ginning machinery, and rice-hulling machinery have been set up and utilized by the ryots to the mutual advantage both of the ryot and mill proprietors.

There are undoubtedly immense possibilities for this class of prime mover in India, and it is very gratifying to note that a good start has been made.

A few decades ago oil was practically unknown as a power fuel ; to-day (speaking generally) it is used in such abundance that some authorities are reasonably questioning whether the world's oil-supply will be equal to ultimate demands.

The same fears have, however, been often expressed in regard to our coal supply, but fortunately the present output of both kinds of fuel is more than ample for to-day's needs, so that power users and engineers alike may safely disregard the controversial questions involved, and continue to make the best of their present opportunities. That the utilization of oil for power purposes has led to the evolution of some fine examples of engineering is a well-known fact, and progress in oil engine construction is still being made. Of oil engines which will economically run on crude oil there are

several good types now on the market, and a short description of one of the latest and best will no doubt be interesting. The engine in question is made by Messrs. Blackstone of Stamford, England, and the sizes at present range from 15 B.H.P. upwards.

In designing this engine the object no doubt was to produce a motor which, whilst working at moderate or comparatively low pressures, should deal with any of the oil fuels found in various parts of the world.

The dual spraying device forms the distinctive feature of this engine. A small air compressor is worked from the crankshaft of the engine, and this compressor delivers its air direct to the spraying valves, but there is in open communication an air bottle which acts as a reservoir. By means of a control valve the air stored overnight in this bottle is used to start up the engine, the bottle containing sufficient air to start several times before the pressure is too much reduced.

The engine operates on the four-stroke cycle, but the charge of fuel is not sent into the combustion chamber until the completion of the compression stroke.

In delivering the full charge direct into the cylinder by compressed air at the completion of the compression stroke, it has been pointed out, "the Blackstone engine resembles the Diesel, but the method of igniting entirely differs."

In the compression stroke of the Blackstone engine the contents of the cylinder consist merely of pure air mixed with residual products of combustion from the previous stroke.

The compression is limited to 150 lb. per square inch, and just at the end of this compression stroke the fuel oil is sprayed into the cylinder and ignited by a flash from the ignitor bulb, which has also received its charge of oil. Instead, however, of the oil being all forced into the cylinder at once giving instant ignition of the whole charge, the oil is gradually sprayed in.

The special feature of this spraying apparatus is that the valves are totally enclosed in a box. The arrangement of the spraying valves in some engines of the crude oil type is for them to work through a packing gland. This, it is said, results in a sluggish action

of the valves, as the packing must be kept well set up, and faulty seating of the valves often ensues. A leakage past the seats then takes place and results in pitting of the valves and seats. In the system under review the valves being enclosed the lever fulcrum spindle works in anti-friction packings, the valves themselves sliding freely in glandless guides ensuring easy and prompt closing.

Forced lubrication is applied to the engine piston and to the compressor piston ; ring oiling bearings are provided on the main bearings, and the crank pin is fitted with a continuous lubricator.

The consumption of fuel oil in this engine is only 0·46 lb. per B.H.P. hour at full load in a single cylinder of 90 B.H.P., with a lower consumption in larger sizes and slightly increased consumption in the smaller sizes.

I have personally tested this type of engine and can vouch for the excellence of workmanship and economical running.

The evolution of the internal combustion engine owing to the vast difference in treatment and ever varying construction undergone probably affords more interesting subject-matter for study than any other branch of engineering, and there can be little doubt that the tendency of the times and the trend of industrial and agricultural evolution are in the direction of human brains and hands finding their chief employment in the designing and guiding of implements and machinery, and the inherent lordship of the human race over materials and over some of the powers of nature appears likely to find its principal method of expression in that way. In the country as well as in the towns the sun of manual labour is setting and the sun of mechanical labour is rising.

THE SUN-DRYING OF VEGETABLES.*

BY

GABRIELLE L. C. HOWARD, M.A.,

Second Imperial Economic Botanist.

IN this paper, I propose to draw attention to a process,[1] recently worked out at the Quetta Fruit Experiment Station, by which all kinds of vegetables can be sun-dried without the use of artificial heat. If suitable methods are employed, a product can be obtained which when cooked is indistinguishable in taste, appearance, and texture from fresh vegetables. The process is simple and inexpensive and can be carried out by any one. It is far easier and cheaper than the usual method of evaporation by artificial heat, and the product obtained is superior. It has the additional advantage of being a truly indigenous industry, for the chief factors involved are the power of the Indian sun and the strong drying winds so characteristic of the western frontier regions.

There would seem to be a real need in India for a supply of good dried vegetables both from a military and a civil point of view. Vegetables are very difficult things to transport on account of their perishable nature and their bulk. It is well known that one of the difficulties in the maintenance of military expeditions in sparsely populated, arid tracts like the North-West Frontier is the supply of this very necessary food. This difficulty was encountered in an acute form at the beginning of some of the early campaigns of the present war, and although it has now been partly overcome it is a difficulty which is bound to recur whenever troops are moved into the very arid regions in the neighbourhood of the North-West

---

* A paper read at the Fifth Indian Science Congress, held at Lahore, January 1918.

[1] For further details, the reader is referred to *Bulletin No. 8, Fruit Experiment Station, Quetta*, 1917.

Frontier of India. In addition, there are garrisons in isolated places like Aden where it is practically impossible to maintain a supply of fresh vegetables. Many military officers have assured me that the provision of really good dried vegetables would make a great deal of difference to the diet of the soldier. Turning from military to civil needs, dried vegetables would be a convenience for shooting expeditions and for officials on tour, and it has also been suggested that large hotels in the hills would be glad to keep stocks of these vegetables in reserve to meet cases of emergency and to supplement the supply of the fresh product. Caravans on the great trade routes of the North-West are another possible outlet for the product. Moreover, places of high elevation in Baluchistan like Loralai have great difficulty in procuring vegetables in winter and the same is true of places like Jacobabad and Sibi in summer. Certain vegetables such as carrots and tomatoes would be useful in the plains in the monsoon to vary the somewhat monotonous diet of gourds and beans which many mofussilites have to put up with for five months of the year. I believe that if really good dried vegetables were offered for sale there would be a steady demand for them all over India.

The most suitable locality for starting such an industry is undoubtedly Baluchistan. Here a very high temperature and a practically rainless summer are combined with great air movement and low humidity. The winds are exceedingly dry and most vegetables can be completely dessicated in less than a day. Moreover these favourable atmospheric conditions occur at a time when vegetables are plentiful. Nearly all English and Indian vegetables grow to perfection in the high valleys such as Quetta and, if proper cultural methods are adopted, the yield is extraordinarily great. As the finished product is so easy to transport it would probably pay best not to start the drying ground at Quetta itself where land and labour are expensive but at some place in the neighbourhood outside the radius of cantonment prices.

I do not propose to describe the method in detail but simply to indicate the main points to which attention should be paid. A full

account of the process has been published[1] and is available if any one requires it.

Good dried vegetables should retain the colour and taste of the undried product, should be tender when cooked, and should be easily preserved and transported. I should like to emphasize the first point because the remark has often been made to me that as long as the nutritive value is unimpaired the appearance is immaterial. It has even been suggested that for military purposes the vegetables might all be ground up and served as a gruel. In the first place, any change in appearance generally means a change in composition and a consequent loss of taste and probably of nutritive value. In the second place, human beings are so constituted that the eye plays a great part in stimulating the appetite. You will see that the samples shown here* are fresh and bright looking and form a much more saleable commodity than the brown nondescript product sometimes obtained. Another popular fallacy is that drying is a method of disposing of old or damaged vegetables. The reverse is the case. Any tendency to stringiness is accentuated by drying and the product formed from damaged material never keeps. Only sound vegetables just ready for the table are worth drying.

The main principles on which successful drying depends are (1) rapidity of drying and (2) treatment of the fresh material by some form of heat. Changes take place very quickly in moist cut vegetable matter leading to discoloration and damage. The use of heat renders the product more tender and helps in the preservation.

The general procedure adopted is as follows—the vegetables having been cleaned and prepared are cut into thin slices and put into fresh water. They are then transferred to a wire basket and steamed or boiled for a few minutes. The length of time varies with the vegetables. Some, such as spinach, require steaming for half a minute only; others, such as potatoes, require boiling in salt solution for several minutes. Green vegetables are boiled in bicarbonate of soda to maintain the colour. A few require steeping in some mild reducing agent such as sodium bi-sulphite.

---

[1] *Bulletin No. 8, Fruit Experiment Station, Quetta.*

* These were exhibited at the Meeting.

The heated product is then spread on trays and dried as rapidly as possible. Success depends on the rapidity of drying, and this is where the advantage of the arid climate of Baluchistan is found.

Suitable trays can be made by stretching *dosuti* (or some similar material) on a bamboo frame. A wooden rim should be provided to prevent the dried produce from being blown away, and in very windy places it is an advantage to have a thin muslin cover over the tray. These covers are nailed to one end of the frame and have a weighted bar at the other so that they can be drawn over the frame. For a few vegetables which scorch in the sun like cabbage, it is an advantage to have a thin black cover instead of a white one.

Boiling and steaming can be quite easily carried out for domestic purposes in two kerosene oil tins fitted one over the other.

The finished product must be perfectly dry and it must be kept dry. The easiest way of doing this is to seal it up in tins.

As dried vegetables are very bulky, it was necessary to find some cheap method of storing and transporting the produce. This was accomplished by steaming and pressing into bricks, one pound in weight and of such a size that they could be packed into kerosene tins which could then be soldered. For this purpose, a suitable press had to be designed. As a result of this, the space taken up by the product was reduced to about one-seventh. Packed in this manner, it is possible to compress the weekly supply of vegetables necessary for a battalion on active service into twelve kerosene tins which can be transported by two mules.

This summer the process has been in full operation in the Quetta Cantonments where a large drying ground has been arranged by the Army. About eight tons of dried product have been prepared and have been sent for trial to one of the brigades on active service.

BEGINNINGS IN INSECT PHYSIOLOGY AND THEIR ECONOMIC SIGNIFICANCE.*

BY

S. K. SEN, B.Sc.,

Assistant to the Imperial Pathological Entomologist.

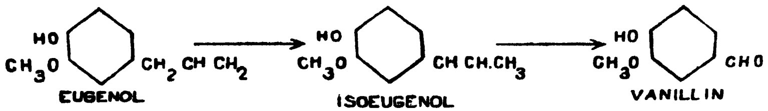
To any trained physiologist anxious to make new discoveries and to assist in the progress of a branch of science which has been too long neglected, in spite of its practical importance, insects offer a most promising field for research. The results to be obtained probably differ, perhaps very widely, from what we are accustomed to expect from workers in the physiology of vertebrates, for the organization of insects may be expected to show some remarkable cases of specialization in both sense-physiology and metabolism. We here put forward merely a few observations designed to show that there is a real field for trained investigators, and that results of interest and of practical value may well reward them. There are of course difficulties.

The small size of the majority of insects makes some kinds of direct observation impossible. and their delicate structure discourages an energetic handling. Add to these the fact that many of them sleep away almost half of the year, sometimes making it difficult to find any trace of them. Then their physiological activities are often controlled to such a large extent by temperature and moisture that an accurate adjustment of the two may be very necessary. Then, again, for many kinds of physiological work, some new kind of apparatus has to be devised and improved by very patient trial. Lastly, the fact that the sense organs of insects, except of course the eye, are still very often not located with any degree of certainty,

* A paper read at the Fifth Indian Science Congress, held at Lahore, January 1918.

sometimes makes an experiment amount almost to groping in the dark.

But such a study is not without an immediately economic aspect, and this is especially so with regard to the significance of specialized feeding habits of insects. The popular epithets cheese-fly, castor hairy caterpillar, etc., are expressive of the specialization that is so often exhibited as to their choice of food. Nowhere in the animal world is more restricted choice in the matter of food noticeable. So it is very natural to enquire : What is it in a particular food that exercises such strong attraction on a particular species ? This in fact is subsidiary to the more general problem of the stimuli that normally control insect activities, and in this line of work the results that have been so far obtained, though small in quantity, involve issues of considerable importance as regards the control of insects. As I had the privilege of assisting the Imperial Pathological Entomologist in his work in this direction, I may refer to one direction in which curious results have been obtained – the definite attraction of certain chemical substances for insects. The males of peach-fly, *Dacus zonatus*, have a strong attraction for oil of citronella. In March or April, 2 or 3 drops of the oil exposed in 500 c.c. of water in a bowl will attract several hundreds of the fly in the course of an hour. Bay oil, oil of pimento, cloves oil also attract them, but to a less extent. Now by a prolonged series of experiments it was found that in all these oils the constituent that attracts is methyl eugenol a substance that is related to the well-known flavouring ingredient, vanillin. The relationship between eugenol and vanillin is indicated by the following formulæ :—



Results somewhat similar to these have also been obtained in the case of some half a dozen other insects, the attracting substances being especially ethers and aldehydes ; but in the present state of

this investigation it would be premature to speak anything about these. The work is necessarily very tedious and progress extremely slow, but the results so far obtained encourage the belief that, when correlation of these results will make a definite conclusion possible, a substantial stride will have been made in the field of applied biology.

In what follows, I propose to mention a few points which have been brought out in the work that I have been doing on mosquitos.

The selection of an insect presented certain difficulties. Ultimately choice fell on the mosquito for the following reasons : (1) its abundance, (2) its short life-cycle, (3) the easiness with which it can be bred in captivity, and (4) the most interesting difference between the feeding habits of the male and the female. But though the experiments were confined to mosquitos, it is hoped that the results achieved will throw light on physiological phenomena that obtain in other members of the insect world.

The mosquito larva is well suited for investigations with regard to osmosis, in view of the probability that its chitin may to a considerable extent answer the requirements of Pfeffer's semi-permeable membrane. In this connexion it may be stated that equi-molecular solutions of cane sugar and common salt act differently on mosquito larvæ, as the following will show :—

(1) 3 grams of $C_{12}H_{22}O_{11}$ and 12 larvæ in 15 c.c. water.

(2) $\frac{1}{2}$ gram NaCl (sea-water strength) and as in above.

(3) $1\frac{1}{2}$ grams $C_{12}H_{22}O_{11}$ and $\frac{1}{4}$ gram NaCl and as in above.

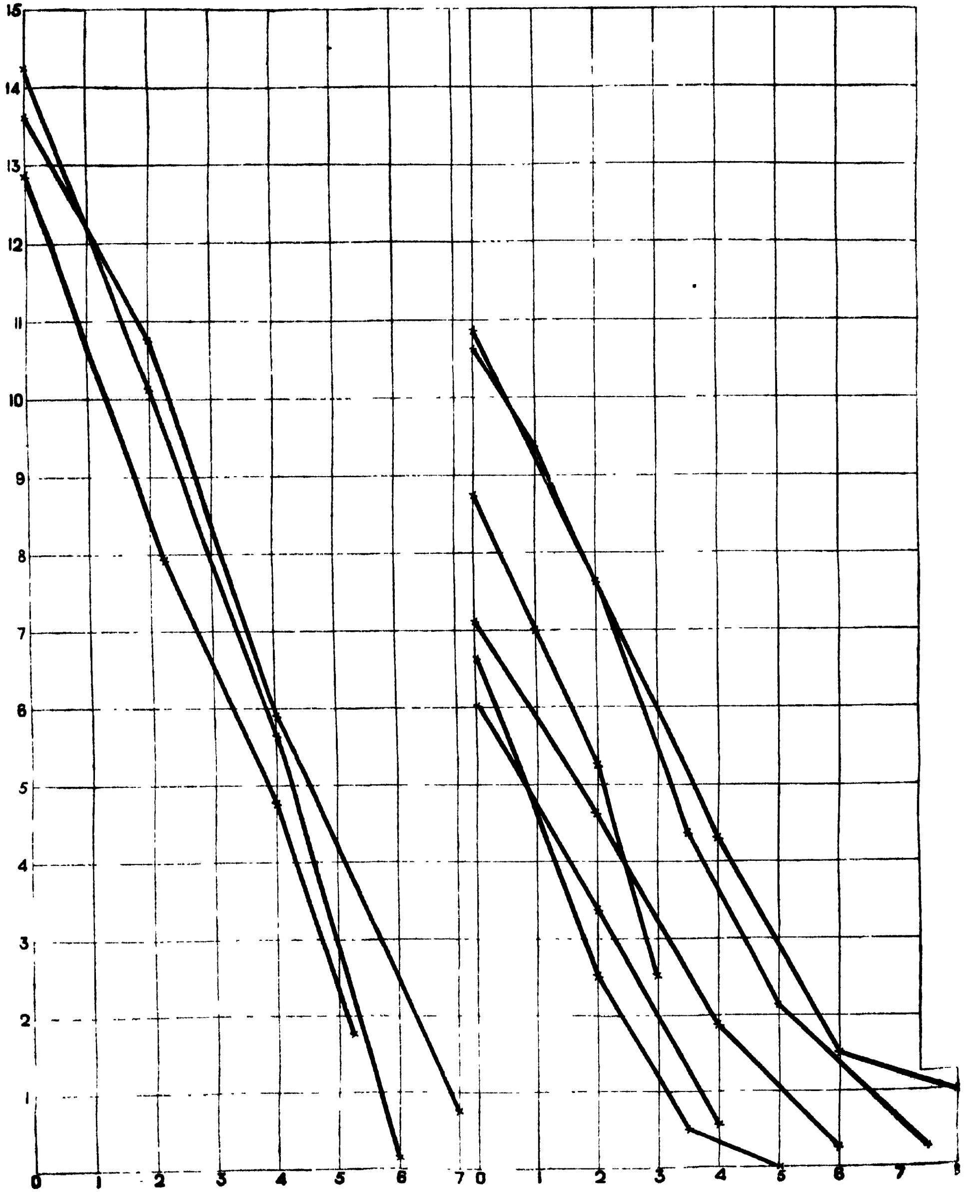
In (1) larvæ died in from 9 to 22 hours.

In (2) larvæ died in about 3 hours.

In (3) they were mostly dead in 9 hours.

The reason for this difference will probably be sought in the fact that sugar is not salt, which latter acts as what is connoted by the obscure term "poison."

I now touch another phase of the physiology of mosquitos : it is their respiration ; and in this respect the mosquito larva exhibits certain interesting characteristics. If a mosquito larva or pupa be kept enclosed with a known small quantity of air, the organism will be alive till practically the entire amount of oxygen in the air



Respiration curves for pupæ of *C. microannulatus* and *S. scutellaris*. The vertical axis represents cubic mm. of oxygen in the bubbles, and the horizontal axis represents time in hours.

is consumed by it.* This will be clear from the curves opposite. The observations were made in a special kind of apparatus devised for the work after a number of rather troublesome preliminary trials. This apparatus could also be used for all air-breathing aquatic insects, such as the larvæ *Syrphidæ*, which are of agricultural interest.

The capability of an insect to consume the whole amount of oxygen present in the air before it dies, is indicative of the thoroughness with which remedial operations on the principle of deprivation of free air from the insect are to be carried out. I refer to such operations as oiling water in which mosquitos breed, spraying insects with soapy or varnish-like substances, covering the warbles of cattle with oily materials, and so forth. The poisons that are to act on the larval spiracles or block the breathing syphons or tubes of the insect should be capable of doing so in a way as not to leave the smallest inlet for the entrance of free air into the insect's trachea.

But these respiration figures have another more general aspect. Respiration is the standard by which the metabolic activity of an insect is generally measured; and if respiration figures could be had with regard to several species of insects, we could construct curves representing the relative consumption of oxygen by insects, and consequently their relative activities at different periods of their lives, the abcissæ and the ordinates representing body-weights and oxygen-consumption respectively.

Unfortunately little has been done towards the elucidation of the nature of the digestive secretions of insects. Plateau discovered the resemblance of the cæcal fluid in the mosquito to the pancreatic juice in mammals; but I am ignorant of the experimental methods he employed, and the literature of more recent work is scattered and not readily available. A beginning was made in this direction by feeding the mosquito larvæ with a simple food of known composition and examining the intestinal contents from time to time. The result of feeding them with euglena was interesting. In some cases,

* A state of affairs which does not obtain in the case of mammals, as Bayliss and others have shown that we die long before the entire amount of oxygen is consumed.

whenever the intestine of an euglena-fed larva was opened, the euglena was found practically in the same state of disintegration, which showed that the larva did not wait for the digestion to be completed before it took in a fresh instalment of food.

Mosquito larvæ seem to thrive well on Sanatogen, which in fact we give to the larvæ that we breed in captivity. We do not know their protein requirements, but the fact that Sanatogen is a glycerophosphate of casein suggests that protein is necessary for its tissue formation. On the other hand, it may, as shown by Bacot, very probably thrive at the expense of bacteria whose presence is the result of putrefaction that follows the introduction of Sanatogen. A freshly dissected out mosquito larva from its natural breeding place displays a heterogeneous mixture of vegetable matter, a very large quantity of silica, and sometimes of other inorganic refuse, which has probably no influence on the insect's metabolic activity. It might also be mentioned that the excreta of the larva after feeding with Sanatogen did not give the murexide test for uric acid.

That the protein requirements of the adults of many insects are practically nil, is proved by the fact that they can live on a simple carbohydrate like a solution of cane sugar—a state of affairs that irrevocably separates the insect from the mammal in which the main function of carbohydrate is the supply of body heat. The extraordinary liking displayed by many insects, such as the mosquito, for sugar, is very interesting. Whereas it is often impossible to humour the mosquito to drinking shed blood, it can be very easily induced to distend its abdomen with a solution of sugar. It is difficult to understand why the mosquito should exhibit liking for two quite dissimilar substances like blood and sugar. The percentage of dextrose in blood is normally from 0·05 to 0·15, which can hardly impart to it any sweet taste, especially in the presence of so many inorganic salts. Even a pure solution of cane sugar, strength 0·15 per cent., does not induce the mosquito to suck. What is there, then, in the blood that encourages the mosquito to suck it? This is an overwhelmingly interesting problem and does, in fact, belong to the more general problem of stimuli already referred to. That thermal stimulus is one of the chief factors that induce the

mosquito to *bite*, has been established by the fact that if a tube of hot water (temperature varying within certain limits with reference to atmospheric temperature) be introduced before the mosquitos, they will energetically prod. But there are two distinct problems which must be carefully distinguished—one of biting, the other of *sucking*. The mosquito will not drink hot water (having the temperature of blood); nor will it drink water as saline as blood; nor even hot saline water. Also it could not be induced to drink shed goat's blood.

From these facts the following conclusions emerge: (1) Warmth, though it actuates the mosquito to bite, does not encourage it to suck; (2) the salinity of blood is not what makes the mosquito to suck; (3) sugar in blood is not what induces it to suck; (4) shed goat's blood is not attractive to the mosquito.

If, in the mosquito, the choice of food is considered in its relation to ovulation, we enter upon somewhat debatable ground. The hypothesis that with mosquito blood is necessary for ovulation, is contradicted by the fact that I have observed in certain cases freshly emerged female *Stegomyia scutellaris* could be induced to oviposit without any meal of blood after being fed on meals of milk, peptone (sweetened with cane sugar), and, in two instances, on meals of cane sugar only. Unless the mosquito had imbibed some special unknown substance from the material in which it bred, oviposition after being fed on substances quite different from blood is evidently possible. Moreover, that the necessity of ovipositing is not the only thing that impels a mosquito to suck blood is suggested by the fact that males, too, try to bite, though they fail to do so.

It is, however, not unlikely that the smelly substances secreted by the sebaceous glands in the skin might be a factor in attracting mosquitos. That food-smell sometimes exercises a strong attraction on insects is proved by the behaviour of *Dacus* to methyl eugenol already referred to. Several other instances may be cited, such as the attraction of *Pycnosoma* for putrefying meat. In this connexion I feel tempted to cite the instance of a typical breeding place of the common blue-bottle, *Pycnosoma flaviceps*. It was at Poona, where I was deputed to investigate the possibility of emigration of

trenching-ground flies into the city. The enormous quantity of night-soil (one of the best foods of *Pycnosoma* maggots) deposited in the several tanks there, emitting a horribly noxious odour, seemed to be responsible for such a huge number of flies. There the total number of flies that I calculated was, roughly, 5,876,666 in 7,500 square feet, and the total number of larvæ, 1,337,650 in 4,200 square feet, the figures in the case of larvæ being obtained by taking counts of larvæ in a square-foot area and multiplying them by the total area, and in the case of flies by dividing the square area of the body of the fly into the total area of ground where the latter was literally covered with flies, allowances being made for areas with lesser numbers of larvæ and flies.

Pycnosoma adults are also very strongly attracted to *mohwa* (*Bassia latifolia*) - a fact which I noticed in the Government Distillery in Calcutta, where I was deputed to investigate a plague of these flies. I could not get any positive information as to the economic loss in the way of reduction of the sugar content of the *mohwa*. As soon as I entered the godown in which the *mohwa* was stacked, I was confronted with a tremendous number of these flies, buzzing and flying and busily sucking the *mohwa*. There were both males and females without any fixed proportion. I vigorously searched for the breeding places, but I could not discover any maggots except a few in the neighbouring refuse-pits. It is not improbable that some of the more distant privies accounted for these flies. It is very likely that the spirit smell of *mohwa* is food-smell for adult *Pycnosoma*, but the flies do not breed in *mohwa*.

The possibility of there existing something of the nature of a stimulus by means of which union, for the purpose of pairing, is effected among insects, has been considered by some scientists. There is an instance of a case in which Sir Hiram Maxim observed that a large number of male mosquitos had congregated at an electrical apparatus that was emitting a particular musical note. The absence of females suggested the possibility of its being a sexual note, giving rise to air-waves that vibrated the antennal whirls of the male in a way as to make him cognisant of the female's presence.

We carried on some partially successful experiments in this direction and improvised an electrically controlled musical apparatus capable of emitting a continuous note of more or less uniform pitch. But our inability to determine exactly the nature of the so-called sexual note has necessitated the postponement of this experiment till we can devise a better type of apparatus. This investigation is of special interest in view of the fact that it is likely to throw light on the significance of stridulation of insects which has engaged the attention of scientists, and which has a highly interesting bearing so far as the control of these stridulating insects is concerned. A method of trapping crickets by means of sound made by striking two coconut shells against each other is common amongst the village boys in some parts of Bengal, but I do not know how far it is successful.

In conclusion, it should be mentioned that no definite generalizations can be made from the insufficient data presented in the foregoing lines; they are nevertheless indicative of the possibilities of this line of work, and it is only as such an indication that they have been presented.

THE USE OF SURPLUS MILK IN A SMALL DAIRY: CHEESE-MAKING.

BY

R. G. ALLAN, M.A.,

Principal, Agricultural College, Nagpur;

AND

J. V. TAKLE, L.Ag., N.D.D.(I.),

Overseer, the College Experimental Dairy, Nagpur.

CHEESE-MAKING, till recent conditions compelled some attention to this branch of dairy industry, could scarcely be considered as a line of development which offered much attraction to those engaged in dairy work in India. Cheese, as it is known in Europe, offered but little attraction to the Indian consumer, as his milk products were practically all associated with the employment of sugar in their manufacture, and his tendency was towards something sweet rather than salt or bitter, while his large utilization of *ghi* (clarified butter) provided the producer with a readily prepared form of milk product which would keep. *Ghi*, manufactured in the East, may be said to correspond to cheese-making in England. In both cases the centres of production are placed comparatively remote from large towns, in places where the sale of the more short-lived products of the dairy is impossible and where grass and grazing are cheap.

Cheese-making, however, appeared to be a possibly profitable outlet for surplus milk in the neighbourhood of towns with a European population, while the manufacture of *ghi* can only be looked on as a means of reducing waste rather than as a profitable enterprise, when compared with milk, butter, *khowa*, and several other products in this environment.

To avoid this waste which was most noticeable in the cold weather when milk was apt to be in excess, and to study the conditions which lead to the production of a good article, experimental work was started at the Agricultural College Dairy some three or four years ago. This paper is a description of such cheeses as have proved satisfactory, with indications of the causes which led to satisfactory results as shown by experiment. The materials adopted have always been of the simplest, as the aim was rather the utilization of surplus milk than the manufacture of cheese as the primary basis of income.

The earlier work was devoted principally to the production of soft fresh cheeses for the local market during the cold weather, though a number of these are now sent to Bombay and other centres and very favourable trade opinions have been received from both Bombay and Calcutta.

Latterly experimental work has been devoted to the production of hard ripened cheeses of the Cheddar type— a type of cheese which it is not particularly difficult to make, but one in which the conditions of curing play an all-important part in the quality of the finished product. Humidity and temperature largely affect results. Success chiefly depends on their effective control. On anything like a large scale in the plains, a special room, designed to control these and yet permit of a circulation of fresh air, would appear to be essential.

In our work, as already indicated, the conditions of manufacture have been throughout as simple as possible, and any of the cheeses described can be made in a small dairy, given the minimum apparatus noted. As surplus milk is usually available in the cooler part of the year—the best time for cheese preparations—they will be found a paying line of business, especially during the present shortage of imports of similar type.

SOFT FRESH CHEESES.

These vary principally with regard to the proportion of cream to milk employed, the length of time allowed between setting and ladling, and the conditions adopted during the draining period.

Differences occurring in the above affect the flavour and the texture and the hardness of the cheese. It is assumed that the milk and cream utilized have been produced and kept under the best conditions, and that scrupulous cleanliness with regard to animals, dairy, and utensils has been maintained, as disregard of any of these will lead to dozens of variations in the quality of the product—most of them objectionable. With the object of distinction we have employed the names Double Cream, Gervais, Single Cream, Bondon, and Lunch for the various types of cheese manufactured and sold from the Dairy. Apart from slight variations in the course of manufacture the leading difference lay in the proportions of separator cream and buffalo milk employed. In the first the proportions of the above were as 1 : 1, in the second as 1 : 2, in the third as 1 : 3, in the fourth as 1 : 8, while in the last named whole buffalo milk only was utilized. The second and fourth were the most popular, followed by the third. The first was too rich and did not tend to develop the flavours found in the next three, and has not been manufactured to any extent of late. Indeed utilizing buffalo milk and buffalo cream, the second appears to be the richest proportion of cream to milk which will produce a really well-flavoured cream cheese. The last on the list, though quite a fair cheese, requires rather closer attention to the time given to setting and is apt to be a little too hard as a cream cheese for the market fancy.

The separated cream utilized represented 16 per cent. of the milk used, and had a fat percentage of approximately 44 per cent. The average test of the buffalo milk was 7·30.

Single Cream (Rennetted).

The processes used for this and the Double Cream were practically alike.

Quantity. Buffalo milk 15 lb., cream 5 lb. Mix thoroughly in a bowl adding a little colouring matter.

Temperature. The diluted cream was brought to a temperature of 65°F. In the cold weather this can be done by mixing and allowing to stand overnight. Otherwise it should be put in an

ordinary ice box or refrigerator which will have a temperature of about 60° to 65°F.

Rennet. The above quantity of cream will require 8 c.c. of rennet solution (prepared by solution of one Hansen rennet tablet in one ounce of water). This quantity should be further diluted before being added to the cream, and on addition should be mixed in thoroughly for about 5 to 6 minutes.

Setting the curd. Cover the bowl with a clean cloth and set at about 65°F. Under these conditions the curd will have set and be fit for ladling in about 6 to 8 hours. Except in the height of the cold weather, if set to curd during the day, the coagulation is best done in a refrigerator. In the Central Provinces in the cold weather the temperature usually ranges from 60° to 70°F. at night, and a curd set late in the evening was fit to ladle at about 6 A.M.

Treatment of curd. When solidification is complete, ladle into clean linen clothes which have just been scalded and cooled and are still moist, putting about 7 to 8 lb. in one bag : and drain as far as possible in a draught. Drainage will take about 48 hours, and can be done during the day in a refrigerator if the air temperature of the room is running about 70°F., and at night in an open room near a window. Provided the temperature is not too high, the more this cheese is drained in the ordinary fresh air of a room the better. Twice daily at least the cloth should be opened and scraped down, mixing the drier with the wetter curd, and the cloth should be changed at least once during the drainage period. By more frequent opening and scraping and by use of a light weight of (say) 3 to 4 lb., drainage may be hastened and reduced to 30–36 hours—a consideration when temperature is difficult to control.

Moulding and salting. Whenever the cheese is firm but pasty in consistency, place the contents in a basin and mix in fine salt using about two teaspoonfuls with the curd derived from the above quantities of milk and cream.

If drying is complete, line the mould with grease paper or muslin and press the curd into the mould till full, then fold over the paper or muslin, add a small weight and apply momentary pressure and turn out the shaped cheese. If it is found that on mixing in the

salt drying is not quite sufficient, the base of the moulds (readily made in the bazaar), which should be perforated and removable, should be covered with blotting paper, cut to size, and the sides lined with butter paper. The mould is filled and the cheese left in the mould under light pressure for 2 to 3 hours and then turned out. In both cases the cheese should be left to stand for 12 to 24 hours on straw mats before covering for market, any paper utilized in the moulding being removed. The cheeses are best sent into the market either in cardboard boxes or surrounded by tinfoil. The moulds used in these cheeses were about 3 in. in diameter and about 1¾ in. high, and the cheese prepared weighed, 24 hours after moulding, about 6½ to 7 oz. Sixteen to seventeen cheeses were made from the milk and cream employed and sold at 8 annas each (Calcutta price). The value of milk and cream was Rs. 5 (milk 12 lb. per rupee and cream 12 annas a lb.), as against Rs. 8 to Rs. 8-8-0 cheese value.

GERVAIS.

Quantity. Buffalo milk 10 lb., cream 5 lb.

Temperature. This cheese requires the milk and cream to be mixed as in Single Cream and brought to 60°–65°F. before the addition of rennet, and it should be maintained as near this temperature as possible during the process of setting and draining. On this account it requires slightly more care and the majority of the work at the Dairy was best done in a refrigerator unless nights were distinctly cool.

Rennet. Using the same standard of rennet as in Single Cream and with the above quantities of milk and cream, only 1 c.c. to 1·2 c.c. of solution should be used, being well diluted before mixing. The quality of the cheese depends on uniformity of temperature throughout, and on the slow rate of setting of the curd due to the small amount of rennet used.

Setting the curd. If the cream is brought to the above temperature in the evening in the cold weather and the rennet added, the curd will usually set by next morning. It requires from 12 to 14 hours from the time of setting to ladling. In the early stages the cream

should be stirred to prevent separation, and the bowl containing the same should stand on wood or non-conductor and not on stone.

Treatment of curd. Hang up the curd in a linen cloth after decanting off as much whey as possible; but do not break up the curd too fine when ladling into the bag. Care must be taken to drain at a uniform temperature and in a place free of draught. Drainage takes about 40 hours, the usual opening and scraping down being done.

Moulding and salting. The curd is ready to mould when firm throughout. After mixing in salt, about two teaspoonfuls to above amount, the curd is pressed into moulds, lined below and round the side with blotting paper, and placed on straw mats. When full, press down and apply a light weight. The curd, if earlier draining was correct, can be removed in one to two hours, but if whey escapes at all freely, leave longer in the mould. The subsequent treatment is as in Single Cream. The size of mould used was about 2¼ in. in diameter, and 1¾ in. high; the weight of cheese on completion was about 4 oz.

In one batch in which 42 lb. milk and 21 lb. cream was employed, 63 cheeses were made. These were valued at 6 annas each. Rs. 19 of milk and cream yielded Rs. 23-10-0 of cheese.

BONDON AND LUNCH.

Generally the points referred to under Gervais hold with either of the above. The general lines of manufacture are the same, with the exception of the proportion of cream and the utilization of small quantity of butter-milk with the milk and cream employed. The quantity for a preparation of Bondon might be taken as 12½ lb. milk, 1½ lb. cream, and ¾ lb. fresh butter-milk. About the same quantity of rennet would be necessary and the process employed would be as described under Gervais. The moulds employed were those used for Single Cream. In one batch where 87 lb. of milk and 11 lb. of cream was employed, 70 cheeses weighing 7 oz. each were prepared, which sold readily at 6 annas each, giving a return of Rs. 29¼ against a valuation of milk and cream of Rs. 15. This type of cheese was found to be the most popular produced—900 to 1,000 being disposed

of during the last season. From a dairy point of view it is also the most profitable.

A similar type of cheese to Bondon but with a different flavour can be prepared with the same proportion of milk and cream and other action by the use of lactic ferment culture instead of rennet.

The Lunch cheese was really similar to that sold as Bondon in England ; but being made from buffalo milk, it was, however, a better article than that usually sold under this name. In order to keep the cheese soft, slightly less rennet must be used than in Bondon. Generally the cheese was slightly more bitter and harder than the above. It was however quite a palatable cheese and had its own market. The Calcutta valuation was 4 annas per 7 oz. cheese, and, as 80 lb. of milk gave 50 cheeses of 6½ to 7 oz. each, the money return was satisfactory.

RIPENED HARD CHEESES.

In describing this the general method of manufacture employed will be detailed, as this, with one or two important variations, was practically the same in all the batches made. These variations were the percentage of fat used in the milk and the length of time allowed for curdling. The other varying factors introduced were brought into play after manufacture was practically complete or during the period of ripening. The introduction of variations in the standard process was directed to overcoming the tendency to hardness and excessive dryness, the results of climate and the use of buffalo milk.

Apparatus employed. One tub fitted with a drainage rack, milk filter, knives for vertical and horizontal cutting of the curd, a measure, thermometer, acidometer, straw mats, cheese-cloths, calico, rennet, weights up to 28 lb., cheese moulds and followers.

Materials. Whole buffalo milk and separated buffalo milk. The acidity at the commencement of the cheese-making should be 0·16. To arrive at this it is usually necessary that one of the above be milk from the previous milking, *i.e.*, the evening before. The proportion of the two used is dependent on the standard of fat adopted. In the earlier work we adopted 3·5 per cent. fat, utilizing equal

quantities of whole and separated milk, and in the course of experiment variations were made between this and 7 per cent. on whole milk only. Eventually a 5 per cent. standard was adopted as correct as far as the fat present influenced the eventual softness of the cheese.

The following may be taken as sufficient materials for two moulds, 14 lb. of skim milk (0·18 per cent. acidity), 30 lb. whole milk (0·13 per cent. acidity), yielding 44 lb. of mixed milk with 5 per cent. fat and approximately 0·16 per cent. acidity.

Process preparing for rennet. Both milks were carefully mixed, tinted by the addition of three teaspoonfuls of colouring matter and filtered. The temperature of the milk was about 75°F. The temperature was raised by immersion of the bucket in a boiler of hot water, stirring the milk during heating. The temperature was thus raised to 84°F. The milk was then transferred to the wooden tub, thereby falling in temperature to 83°F.

Rennet. Rennet was added, 6 c.c. of standard being diluted with six times its bulk of water. The rennet was made up by using one tablet of Hansen's rennet in ½ oz. of cold water in which a teaspoonful of fine salt had been dissolved. It corresponds to about one dram of standard rennet per three gallons of milk. After addition of rennet the milk was gently stirred for 3 to 4 minutes, and then covered with a cloth and left to curd.

Cutting the curd. The curd set and was ready for cutting in from 35 to 40 minutes after the addition of rennet, being regarded as ready when it broke with a clean fracture when the thermometer was inserted. At this stage the curd was cut vertically and horizontally into cubes of above ¾ in. side. The curd was then stirred and allowed to settle for 15 minutes, a muslin was pressed down into the tub which caused a clear whey above. About six quarts of whey was removed and heated to about 90°F. The warmed whey was gradually added to the curd and whey in the tub, the curd being stirred, till in about 20 minutes it was raised to 86°F., at which temperature it was maintained for 30 minutes. The whey was then poured off and the curd transferred to a cheese-cloth and placed on the rack to drain for 20 minutes, the acidity of the whey being 0·13 per cent. The

curd was cut into cubes of three sides and allowed to drain again for 20 minutes. This was done in all three times, the size of the cube being reduced by about 1 in. on each occasion. The curd at this stage should begin to crumble down into small flaky pieces when passed between the finger and thumb. The weight of curd was 8·4 lb. The curd was crumbled down partly by hand and partly by the use of a mortar and light pestle, salt at the rate of about one ounce per 3 lb. of curd being gradually mixed into the curd. The curd was now ready for moulding. The moulds used were 6 in. in diameter and 5 in. in height, a size which we considered would be satisfactory for the sale of whole cheeses to customers, but which, later observation showed, would have been better if they had been an extra inch at least in diameter, as the small size employed undoubtedly accelerated drying. The mould was lined with cheese-cloth and the curd gradually added and pressed in. When full the follower was placed on top and 14 lb. weight applied. After two hours the cheese was removed from the moulds, turned, and replaced, this time with 28 lb. pressure, and left overnight. Early next morning the cheeses were removed, the cheese-cloth taken off and a piece of calico sewn round the cheese. They were returned to their mould and subjected to 28 lb. pressure for two hours and finally removed and placed on straw mats to dry. This required about 24 hours. They were then ready for ripening, during which they were turned twice daily. The cheese was in good condition for use in from six to seven weeks and weighed about $2\frac{3}{4}$ lb. to 3 lb. 2 oz. per cheese. The first batch made had a 3·5 per cent. fat, and the curing was done in an underground cellar during the day and night at a temperature of 80°F. The cheese in this case, on completion, weighed 2 lb. 12 oz., and, though the flavour was fair, the cheese was distinctly hard and did not have the melting effect in the mouth associated with a good cheese. On the other hand the next experiment which was carried on it on almost similar lines with $3\frac{1}{2}$ per cent. fat was an exceptionally good cheese, each weighing just on 3 lb.; the only variant in its manufacture was a steadier curing temperature which remained at 60°F. for the first four weeks. Variations were made in the percentage of fat. The whole buffalo milk gives a larger weight of cheese for milk used and also a softer cheese but

with less of the consistency of the Cheddar type. It might be described as soft to cut but somewhat powdery to eat. High fat percentage tended to a distinct melting out of fat during ripening. This was noticeable in all cases above 5 per cent. when the weather began to warm up in February. Experiment was made on altering the time of setting of the curd from the standard of 35 minutes first aimed at up to 70 minutes. Lengthening the time of rennetting tended to the production of softer finished cheese, but did not have as much effect in this direction as certain other factors, and almost as soft cutting cheeses with a mellow melting character were got with 35 to 40 minutes' rennetting when conditions of moisture and temperature during ripening were suitable. Altering the pressure applied in the press by decreasing the first time under 28 lb. weight to 3–4 hours, thus avoiding so complete an expression of whey, produced a cheese with less hard and dry character. Experiments conducted in paraffining the enclosing calico with melted white paraffin about 8 to 10 days after making had the effect of preventing excess loss of moisture during curing and resulted in softer cheese, but our observations lead us to look on this rather as a means to avoid unsatisfactory curing conditions than as an essential for a good cheese. Strict maintenance of the temperature at 60° to 65° F. by doing curing almost entirely in the ice-box—a condition forced on us by rising air temperature—together with the presence of water in the cooling chamber, had undoubtedly a very marked effect on the quality. All the last three batches of cheese, in which this was controlled, whether set for 35 minutes or 70, or whether enclosed in paraffin or not, were good with a slight bias in favour of those paraffined. A very marked improvement took place in the quality of the cheese (5 per cent. fat) prepared in these batches, when after short applied heavy pressure and six weeks' curing, under conditions noted, they were transferred to air-tight vessels (in our case laboratory drying jars without the drying material), and left with occasional turning for about a week, the temperature being about 80°F. The cheeses so treated appeared to soften very considerably, developing a better texture, quality and flavour without further loss of moisture.

For this class of ripened cheese as described, we are of the opinion that the following variations in the standard method described will tend to help towards a really good quality hard cheese :—

The use of milk containing 5 per cent. fat, an increase in the time of setting from 35 minutes to 45 or 50 minutes, strict attention to curing temperature and its steady maintenance at 60° to 65° F.—all cheeses in which a higher or irregular curing temperature existed were harder and drier—the maintenance of some vessel containing water in the curing chamber, the reduction of time under heavy pressure, and, finally, the removal of the cheese after six weeks in the above condition to a chamber which is air-tight or practically so at higher temperature for a week. The application of paraffin during curing, so as to check the loss of moisture from the cheese, is not essential ; but on the completion of the curing process a heavy coating of paraffin is no doubt of value in storing the cheese.

COMMON CONTAGIOUS CATTLE DISEASES AND METHODS OF DEALING WITH THEM.

BY

R. BRANFORD, M.R.C.V.S.,

Superintendent, Government Cattle Farm, Hissar.

RINDERPEST.

SINCE I have been in charge of the Hissar Government Cattle Farm, I have had two opportunities of observing outbreaks of rinderpest, and the following facts noted in their connection may prove of some interest.

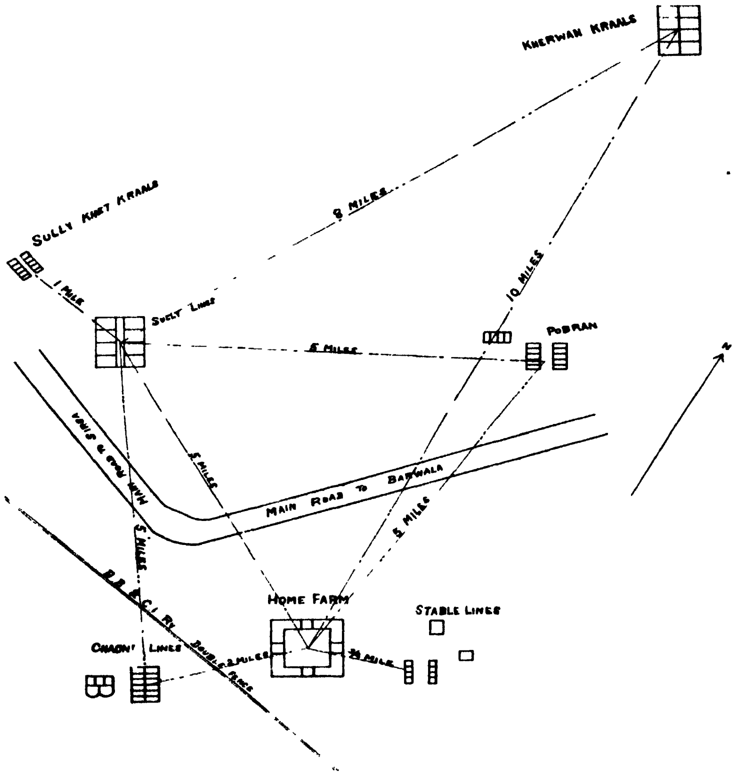
The map below (p. 640) shows the places where cattle were attacked and the approximate distances from Hissar and each other.

The first outbreak occurred in June 1914 at Sully. At that time, at Sully, there were 250 cows, all with big calves at heel, and 20 herd bulls.

The cows were in four herds in separate lines; the bulls were in a separate line, but four of them were running with the cows at night.

The previous monsoon rains had failed, and the cows were all in very poor condition; the bulls and calves were fat. The disease was definitely diagnosed on June 3rd, after which all the animals were kept up and stall-fed, and the affected animals were placed in a separate line. All except affected animals had to be taken out to water twice daily at a tank about 300 yards from the lines. Serum was at once telegraphed for, but, owing to delay in its arrival, inoculation of these cattle did not begin till the 13th. Inoculation of cows and bulls finished on the 19th. The disease spread rapidly.

According to a diary I kept at the time, two cases were noted on the 3rd, and 22 by the 9th. Altogether there were about 40 cases, of which 14 died. Five of the bulls were affected ; none died.



No case occurred among calves until the 23rd ; they were inoculated on the 25th and 26th. None of the calves died.

The serum was used in doses of 30 c.c. for bulls, 20 c.c. for cows, and 10 c.c. for calves.

The average weight of the bulls was about 1,500 lb., and of the cows about 900 to 1,000 lb. (cows on this farm average more, but these were in poor condition). The calves were of varying ages, mostly about 5 to 6 months old.

The serum acted well, and no animals unaffected at the time of inoculation died or showed serious symptoms.

No drug treatment was tried on any of the cases, but all through the outbreak the cattle were well fed on as much green *jowar* (*A. Sorghum*) as they could eat. In my experience plenty of good green fodder is the best treatment for rinderpest.

The weather throughout June and up till July 5th was hot and dry.

The chief point of interest in connection with this outbreak was our success in limiting it to the place where it started. It did not even spread to the bullocks of the Sully cultivation, which had to work in fields about half a mile distant from the cows' lines, and had to be watered at the same tank. These bullocks also had to bring the cows' ration of green *jowar* up to the lines. The delayed infection of the calves was curious, considering that some were actually being suckled by affected mothers. Probably the great heat and dryness rapidly sterilized the virus, and had more to do with limiting the outbreak than the very strenuous efforts which were made by way of isolation and disinfection of attendants, utensils, etc.

Rinderpest did not occur on the farm again till May 1917. In March 1917 some cases among buffaloes were diagnosed in Hissar town, and a number of deaths occurred. As many as possible of the animals in immediate contact with the diagnosed cases were inoculated by the Civil Veterinary Department, and so far as I am aware this outbreak did not spread much among other cattle in the town; but outbreaks in neighbouring villages were reported frequently throughout April.

The farm *bir* (grazing land) is traversed by numerous public roads, and it was soon obvious that the disease must soon spread to farm cattle. This did not actually occur till May 4th, on which date some of the young male stock at Chaoni were found to be affected.

There were 825 animals in contact, aged 1 to $3\frac{1}{2}$ years. Serum had been obtained, and all preparations for inoculation had been made beforehand, and all were inoculated by the 10th.

This may seem a long time for so small a number, but the animals were all wild and unhandled, and could only be inoculated after lassoing and pulling up to a gate. The older animals are very strong, and the men have generally had enough by the time 100 have been done. Also, by the serum alone method, which is the only method allowed in India, if one goes too fast through a big lot of cattle kept in separate herds, as these are, it is difficult to insure getting all the inoculated animals into contact with the disease before the period of immunity conferred by the serum passes. Unless one does, inoculation with serum alone is almost waste of time.

Altogether about 50 animals contracted the disease with definite symptoms. About half were definitely affected prior to inoculation and were not inoculated, and some of the remainder were probably in the incubation stage of the disease at the time of inoculation. Eleven of the animals died. The disease was in some cases complicated by foot-and-mouth disease lesions, and in all cases was aggravated by flies. Flies are usually absent in May, the fierce dry heat and hot winds being too much for them; but May 1917, in fact the whole of 1917, was abnormally damp. Rain had been heavy in April, showers occurred in May, the weather was always close and muggy, and flies swarmed.

Maggots had to be removed from the mouths and parts surrounding the anus from all severe cases, and the wounds made by them dressed twice daily, involving the lassoing and casting of each case for each dressing. Under normal conditions no doubt the percentage of deaths would have been less.

The disease was next discovered on May 18th at Kherwan (10 miles from Hissar) among a herd of 612 heifers aged 1 to $3\frac{1}{2}$ years.

The animals were in temporary thorn kraals, and there being no facilities for catching up and inoculating on the spot, they were brought in herds day by day to the Stables lines and inoculated there. Severely affected cases were kept at Stables for treatment. Some mild cases were returned to Kherwan with the others, in order to allow of the inoculated animals keeping in contact with the disease. About 30 working farm bullocks were at Stables in a line adjacent to

the one used for the severe cases. These bullocks were also inoculated. As regards treatment, the same difficulties with maggots were experienced as at Chaoni. Deaths occurred in about the same proportion.

There were no further cases among farm animals until August 7th, but reports of the presence of the disease in neighbouring villages continued to be constantly received throughout the hot weather and rains. On August 7th the disease was diagnosed at Sully in a herd of 206 young stock bullocks, $2\frac{1}{2}$ to 4 years old. Seven animals were affected. There were about 1,000 cows in temporary thorn kraals on the Sully cultivation, about three-fourths of a mile from the lines where the young bullocks were, and about 20 herd bulls and 10 young three-year old bulls were in separate adjacent lines. In the hope that the cows, of which 80 per cent. were heavy in calf, might escape infection, the affected herd of bullocks was moved to Chaoni and inoculated there. Cases of the disease were also moved and treated at Chaoni. The bullocks were necessarily, while grazing in the day time, mixed with the young male stock at Chaoni which had been inoculated in May. A few days after inoculation, as usual, several of the bullocks which were probably in the incubation stage at the time of inoculation, showed definite symptoms of the disease, and a large proportion of the young male stock must have again come in contact, but none of them ever showed the slightest symptom of the disease. The inference is that they had acquired active immunity from inoculation with serum alone plus contact in May. On August 22nd rinderpest was diagnosed in one of the 10 young bulls at Sully. All ten were removed to Chaoni. The nine healthy animals were inoculated, and all were kept in the same line with the bullock cases. The affected bull, after becoming convalescent from rinderpest, contracted pneumonia and died.

On September 11th the disease was discovered at Pobran in a herd of 200 cows with calves at heel. There were also at Pobran 500 cows heavy in calf (these animals had been moved there from the Sully cultivation in August), but their kraals were separate from the affected cows. Only the cows with calves and the calves were inoculated.

On September 30th, cases of the disease were again found at Sully among a herd of 200 cows with small calves which had recently been transferred there from the home farm where they had been for the previous three months. On the same day more cases were also diagnosed in a herd of 90 cows, with small calves, at the home farm. Both herds and also all contacts at the home farm and the calves were rapidly inoculated.

On October 9th the disease was again found at Pobran; this time in the pregnant cow herd. Most of the very heavily in calf animals had duly calved and been inoculated at the home farm in the interval between the previous outbreak there and this. The remainder were now inoculated, and although some were heavy in calf, and all were wild and had to be lassoed and hauled up to a gate, no abortions occurred. There was no further outbreak on the farm until November 18th, when three of the bullocks at the Stables cultivation were found with severe symptoms of the disease. The remaining bullocks there (30 in number) were inoculated on the 19th and one more case occurred. Two of the three first attacked died. As mentioned above, these bullocks had been previously inoculated in May. Presumably although standing at night in a line adjacent to one containing cases of the disease, and being inoculated in a yard in which numerous affected animals had been handled the day before, they had not been at that time sufficiently in contact to acquire active immunity.

The heifers, which had also, as described above, been inoculated in May at the same time as the bullocks, had been brought to Stables from Kherwan at the beginning of November. They were in daily contact with the affected bullocks, but none of them contracted the disease, and presumably they had acquired active immunity in the same way as the male stock at Chaoni did.

In the above record the following points seem to me to be of special interest :—

1. The demonstration that the serum alone method plus contact with the disease does produce an active immunity. Muktesar experiments of course have previously definitely proved this, but experiments under laboratory conditions are very different to dealing

with large numbers of animals in the field. Actual mixing of diseased and healthy inoculated animals seems necessary to produce active immunity. The Stables farm bullocks, when inoculated in May, stood for over a month in a line separated from another containing severely affected animals, several of which died, by a wall about one foot thick perforated with numerous holes 8 or 9 inches in diameter. They were caught for inoculation in a small yard in which numerous cases of rinderpest had been caught the day before, but they did not develop active immunity and were attacked by the disease in the following November.

The heifer and male stock herds, which did develop active immunity, were not inoculated until cases had occurred, and were mixed at time of, and after, inoculation with mild cases of the disease.

2. The slow spread at times of the disease from herd to herd even when the herds are in close proximity is interesting; much of this may be due to the degree of immunity possessed by Indian plains cattle, but in practice rinderpest does not appear to be so highly contagious as most text-books lead one to believe, at any rate in India, and suggests that in the absence of serum a good deal could often be done to check the spread of the disease by segregation. In the outbreak after inoculation of the affected herds on the farm in 1914, segregation was completely successful in preventing further spread of the disease. In 1917 probably I would have had less trouble if I had artificially infected and inoculated the various herds as rapidly as possible, but I do not think any of the numerous farm outbreaks were due to spread of infection by farm animals or attendants. The disease was general throughout the district; all the villages surrounding the farm at one time or another became infected. The farm *bir* is unfenced, and all the villagers surreptitiously graze their cattle in it as often as they can. The *bir* is also traversed by numerous roads on which traffic cannot be prohibited. Probably each outbreak was due to fresh infection from outside. Conditions in India with its tiny Veterinary Department, and where it is at present impossible to enforce restrictions on the movement of animals, are of course much against attempts to check the spread of disease by segregation.

3. A table is given below showing the number of animals inoculated in the various outbreaks and the numbers which died. Most of the animals which died or became severely affected were inoculated or probably affected at the time of inoculation. (Inoculation of affected animals with preventive doses is not recommended, but during the first few days animals affected with rinderpest show no symptoms except a rise of temperature and in dealing with unhandled cattle the taking of the temperature is as difficult an operation as performing an inoculation. The animals have to be rounded up in a small yard, lassoed and hauled up to a gate, after which the temperature is not a very reliable guide. The routine practice on this farm is to inoculate all animals not showing definite symptoms. This necessarily involves inoculating a small proportion already affected.) In 1917 the virus was probably unusually virulent, and a number of animals did contract the disease 10 days or so after inoculation, and were undoubtedly healthy at the time of inoculation. The serum was used in doses of 10 c.c. for calves under 1½-year old, and 15 c.c. to 20 c.c. according to size for other animals, excepting herd bulls, some of which received 40 c.c. doses.

In 1917 the percentage of deaths to cases was for plains cattle high. It is not possible to give exactly accurate figures, as some animals developed the disease in an exceedingly mild form, and showed few or no symptoms beyond a temperature reaction, and as they were unhandled few temperatures were taken and some cases no doubt evaded diagnosis. The mortality was probably about 40 per cent. Unfavourable weather conditions, maggots, and in some cases complication with foot-and-mouth disease rendered treatment unusually difficult, and probably raised the mortality percentage.

Number inoculated	Number died without inoculation	Number died after inoculation*
4156	30	37

* A large proportion of these, as explained above, were probably really in the initial stage of the disease at the time of inoculation.

HÆMORRHAGIC SEPTICÆMIA AND BLACK QUARTER.

Both these diseases are endemic in Hissar District. During recent years deaths from them on this farm have been as follows :—

			H. S.	Black Quarter
1912-13	...	Dry year	5	12
1913-14	...	,, ,,	—	29
1914-15	...	Wet ,,	58	7
1915-16	..	Famine ,,	—	19
1916-17	..	Wet ,,	18	5
1917-18	...	Flood ,,	68	26

Both are mainly diseases of young stock ; I have never had a case here of black quarter in a cow, herd bull, or cultivation bullock. Cows and bulls here are not so described till they are over 3 years old, and cultivation bullocks not till they are over 4 years. Hæmorrhagic septicæmia does, especially at times of severe epidemics among calves, occasionally attack mature animals. Probably in both diseases the younger the animal the greater its susceptibility. Black quarter is said to be rare in sucking calves, and my experience here bears that out, although a few cases as a rule occur annually, but that is probably because natural infection is in some way connected with grazing. Young calves for the first few months do not graze much. The most serious epidemics of hæmorrhagic septicæmia here have always been in calves under their mothers, generally aged between four and eight months. Infection in their case is almost certainly by way of the mouth ; calves here as a rule get no opportunity to graze till they are over two months old, and as a rule do not graze much when they have the opportunity till they are over four months.

Both diseases as regards measures necessary for prevention are similar, in that both are usually contracted by animals being grazed over infected areas. The degree of danger in the areas depends, especially as regards hæmorrhagic septicæmia, on rain, and the disease as a rule here only occurs after good monsoons in the autumn. Exceptions to this rule are probably due to flooding of low-lying areas by canal water. An outbreak which occurred here in December 1911 (a dry year) was almost certainly due to this cause. Colonel Farmer informed me that in connection with this

outbreak, he fenced off a low-lying area in proximity to the canal and subject at times to floods of canal water. After the fencing (made of thorns) was complete the disease stopped. Some months later, parts of the thorn fence were blown away in a violent dust-storm, and some cattle got into the place and cases of the disease again occurred.

Both diseases can usually be checked if on an outbreak a complete change of grazing to high, well drained ground can be effected. As regards this farm, at times of heavy general rainfall this is very difficult, as low-lying areas are scattered all over the *bir*. It is especially difficult in outbreaks occurring at Chaoni among the male stock, as their grazing area is comparatively small, and with the small number of both cattle herds and supervising staff available, it is practically impossible to prevent the cattle grazing where they like. Specially known dangerous areas are sometimes fenced off.

In the case of outbreaks among heifers or calves with cows which are grazed to the north of the B. B. & C. I. Railway line (which runs through the *bir* roughly east to west), complete change of grazing can be effected as the area is very large, but in no case can one ever be certain that the cattle have absolutely no access to low-lying dangerous ground.

In cases when moving to fresh ground is ineffective, and serum for inoculation is not available, both diseases can sometimes be stopped by keeping the animals up and stall-feeding them. In my experience here, this always stops black quarter, but cases of hæmorrhagic septicæmia sometimes continue to occur several days after animals have been kept up. Lack of precise knowledge as to the natural method of infection and period of inoculation prevents any conclusions being come to from such incidents, and in my cases the experiment has never been continued very long. It has only been done here on occasions when, for some reasons, serum was not immediately available. Animals here are always inoculated as soon as possible if change of grazing is not effective.

If inhalation, as text-books say, is ever a natural method of infection, such cases are easily explained. I have frequently seen

animals in the last stages of the disease lick healthy ones standing near, and shake saliva over them, but have never been able to trace any case of the disease to this cause.

In September 1914, a particularly severe outbreak of hæmorrhagic septicæmia occurred here among calves at heel. The outbreak began at Pobran. The affected herds were first moved to Stables and grazed from there, but as deaths continued, after two days they were kept up and stall-fed. Deaths still continued for three days, when serum which had been telegraphed for arrived, and the animals were inoculated.

Serum immediately stopped the outbreak, and no calf died more than 36 hours after inoculation. Altogether about 350 calves were concerned, of which 50 died, all but three before inoculation.

In September 1916 the disease started among the heifer herd at Kherwan. The affected herd was inoculated, and whole of the animals—10 herds of about 70 each—were moved to Sully and no more cases occurred.

In the autumn of 1917 hæmorrhagic septicæmia occurred on the farm to an altogether unprecedented extent. The first outbreak at Pobran was among calves about 7 to 8 months old. The first case was diagnosed on November 1st. Four died on the 2nd, two on the 3rd, and three on the 4th, all uninoculated. The herd was inoculated on the 3rd. (Arrangements had been made to inoculate them on the 2nd, but they stampeded on the road to the inoculation yard.) After inoculation the calves were kept up and stall-fed, but four inoculated animals died on the 5th, two on the 7th, and one on the 15th.

Serum was not so effective as usual, but probably the animals which died on the 5th were already infected at the time of inoculation. The animal which died on the 15th showed pronounced symptoms on the 13th, and after 24 hours appeared to be recovering.

The disease next started at Sully on the 13th November among a herd of 125 calves at heel (about 4 months old). They were inoculated on the 15th. Cases also occurred at Sully on the 15th and

16th in two herds of older calves of about 70 each, also under their mothers. They were inoculated on the 16th and 17th.

Altogether at this time there were 850 calves at Sully, with their mothers, from three to seven months old, divided into twelve herds. Cases occurred in all but two of these herds before December 17, and they were inoculated. On the whole the results of inoculation were satisfactory, and some of the deaths which occurred were in calves not fully recovered from rinderpest, and some cases were complicated with piroplasmosis.

On the 18th November a case of hæmorrhagic septicæmia was diagnosed in a herd of 100 heifers at Stables and grazing was changed. On the 23rd November another case occurred in another herd of 90. These were also sent to a fresh grazing ground. No more cases occurred in either of these herds. On 26th another case in a herd of 100 occurred and grazing was changed, but another animal died on 27th ; both animals were probably infected on the same ground, but the animals were the youngest heifers there, and probably the most susceptible, and were inoculated on the 27th. No more cases occurred at Stables ; there were altogether 6 herds of heifers there.

On December 2nd the disease started at Chaoni among the male stock. Two cases were diagnosed in a herd of two-year-olds. There were about 550 animals there under three years old, all were inoculated as quickly as possible, but the disease spread rapidly and several deaths occurred before inoculation was completed. Four deaths occurred in inoculated animals several days after inoculation, and the dose of serum in last herds inoculated was increased to 20 c.c. (The dose, usually used on this farm, of hæmorrhagic septicæmia serum is 15 c.c.)

The disease did not spread to a herd of 200 young stock bullocks which were being grazed over the same ground as the male stock. Very few of the bullocks were under three years old and about half were four and over.

Cold did not seem to have any effect in sterilizing the ground ; sharp frosts occurred in December and January, but one or two sporadic cases occurred in January among young cows. Black quarter, as the above statistics show, occurs here practically every

year. Moisture does not appear to have much effect on the incidence of the disease. As a routine practice, all cattle on this farm are vaccinated against the disease at the time of weaning (6 to 9 months old). This as a rule keeps the disease in check, but cases are always liable to occur sporadically, generally in animals about 18 months old which have lost the immunity conferred by vaccination at weaning. Usually also there are one or two cases annually in calves before weaning.

In the two years 1913 and 1917, in which deaths were most numerous, regular outbreaks of the disease occurred at Chaoni among the male stock. On both occasions re-vaccination of all susceptible animals there was carried out. I was away on leave at the time of the 1913 outbreak, but the result of vaccination was satisfactory.

The 1917 outbreak occurred in June and immediately assumed serious proportions. Pending arrival of vaccine, the grazing grounds of the cattle were changed as far as is possible at Chaoni, but deaths continued, and after a day or so the cattle were all kept up and stall-fed. After vaccination each herd was kept up a further period of ten days, and then sent out to graze anywhere they liked. No deaths occurred after the animals were kept up, and no deaths from black quarter have occurred since up to date (February 1918) in these animals.

A case of black quarter occurred in a 2½-year old bullock grazing with these animals in August. The bullock had been sent to Chaoni from Sully owing to rinderpest.

The effect of vaccination is not always so satisfactory as in the above instances; recently (February 1918) four calves aged about 10 months have died, which were only vaccinated in January. Probably the immunity conferred by the vaccine varies with each brew. These animals were also at Chaoni, showing that black quarter infection is still alive there. Most of the animals inoculated in the June 1917 outbreak were still there, presumably they still retained some of the immunity acquired by vaccination in June.

Several cases of black quarter also occurred in 1917 among the heifers at Kherwan late in October. The animals were moved

to Stables, which necessarily involved complete change of grazing. This effectively stopped the outbreak; two heifers died of the disease within 48 hours after arrival at Stables but no doubt were infected before leaving Kherwan.

IRRIGATION IN SIND.

BY

T. F. MAIN, B.Sc.,

Deputy Director of Agriculture, Sind.

THE province of Sind consists of some 30 million acres of land of which some 15 million acres are culturable, but the annual cultivation amounts to only $3\frac{1}{2}$ million acres in a good year. For practical purposes the agriculture of the country depends upon irrigation as the rainfall is almost negligible. It is only in two tracts, *viz.*, the Desert and Kohistan, that a precarious system of agriculture dependent on rainfall exists. Through the middle of Sind from north to south flows the Indus river which drains the Punjab in addition to carrying the vast volume of melted snow water which issues from the North-West Himalayas. It is largely this snow water which brings about the annual inundation of the river that extends from May to September. Soon after entering Sind the river passes through the Sukkur gorge, and it is at this point where the most favourable conditions are found for withdrawing water to irrigate the province. The great scheme known as the Sukkur Barrage and Triple Canal Project is now receiving the earnest attention of Government but has not yet been sanctioned ; still it seems safe to predict that another decade will see the work approaching completion. Sind is a great alluvial plain intersected by the river which formed it. The land is fertile save for certain salt and sandy stretches and has great potential qualities. High class samples of wheat and long-stapled cottons have been produced experimentally ; the rice has a reputation extending far beyond the boundaries of Sind, and the *jowar* (*A. Sorghum*) crops are perhaps the finest seen in India. The great possibilities of the province are only very partially realized and

the cause is primarily the lack of irrigation. The water is there in the river, but it is allowed to pass on to the sea. At the height of the inundation season some 500,000 cusecs pour through the Sukkur gorge of which some 45,000 cusecs are withdrawn from the river below this point. The river is at its lowest from December to March. Even then 20,000 cusecs pass the Sukkur gorge, and practically none of this is brought on to the land. The great project referred to above is intended to rectify this unsatisfactory state of affairs by withdrawing 17,000* cusecs of water in the *rabi* (winter sowing) season, and it will also provide for the regular and steady supply of water to the great canals throughout the year. At the present time there is only one perennial high level canal in Sind—the Jamrao. The inundation canal system supplies water mostly below the level of the land (except in rice tracts). All this will be transformed when the new high level canals of the scheme referred to above come into use.

From these remarks it will be evident that the Irrigation Department is going to fulfil its rôle of making the water of the Indus available for cultivation in the best possible manner. Three-fourths of the minimum cold weather discharge will be diverted into canals, with alignments coinciding with the crests of the slightly undulating plains so that the water will flow on to the land under the force of gravity and require no lifting, while a constant supply will be ensured both as regards time and quantity. When these conditions prevail cultivators will be in a very enviable position, but the greatest care will have to be taken to see that the water is well used and not abused. It must be fully recognized that this scheme has dangerous possibilities. The water table is bound to rise, and it is essential that this rise should be kept within limits and not unduly accelerated by the lavish use of water where it is not required. Such a practice would undoubtedly lead to large tracts of country becoming water-logged or *kalar* (alkali) infected or both. It is in this connection that the Agricultural Department has an important function to perform. It must convince the cultivator

* This includes 2,000 cusecs at present withdrawn above the gorge for *rabi* cultivation.

that working with a minimum application of water is to his interests, both directly as affecting yield and quality of produce and indirectly in preserving his lands from ruin. It is a commonplace that where there is an abundant supply of cheap canal water cultivators flood their fields more because the water is at hand than because their crops demand it. This practice is common in Sind where the conditions permit and the consequences are obvious.

On the area commanded by the Jamrao the texture of the soil is fine, and there appears to be a great amount of invisible salt impregnation quite apart from the *kalar* patches which so forcibly strike the eye. A great deal of the land has in consequence the properties of a very stiff working soil, though not a clay by constitution. Such soils are difficult to farm; irrigation water stands for many hours or even days before it becomes absorbed; then the surface dries rapidly and bakes into a hard crust impenetrable to air; cracking follows and in the worst cases the ground has the appearance of a cobbled pavement with intervals of half an inch between the adjacent stones, themselves perhaps eight inches or a foot in diameter. As there is no practice of intercultivating or harrowing standing crops, the condition described above, developed to a greater or less degree, is a common sight a few days after a crop has been watered. It is unnecessary to enlarge upon the adverse conditions for root development and crop growth which are brought about in this way, but it may be observed that they could hardly be worse. Moreover, in such soils subsoil capillarity is very weak, and in the circumstances crops can only survive by frequent irrigations which soften the surface and nourish the surface roots which are all that remain of the root system. Fortunately this is not a universal state on the Jamrao area, but it is common and widely distributed and interlaced with free working soils. The latter are very fertile and easy to work, they are retentive of moisture, and capillary action in the subsoil is very active, but they also cake on the surface with irrigation; on such soils it is possible to raise excellent crops on a very small amount of water most of which can with careful management be applied before the seed is sown.

The work for the Agricultural Department, which this diagnosis of the position suggests, falls into two classes :—

(1) The demonstration, with the aid of suitable implements, of improved methods of grading and levelling the land and of tillage, designed with the object of raising full crops with the minimum amount of water applied to the land as largely as possible before sowing the seed.

(2) The demonstration of methods calculated to improve the texture of the soil where it has been injured by the impregnation of *kalar* salts.

In this paper it is only proposed to deal with the first of these operations and to report some results which have been obtained at Mirpurkhas in the saving of irrigation water. The work was conducted on broad lines and not as a watertight experiment. The area devoted to this investigation was about 50 acres of land all of which was cropped with wheat. The land in question produced a 7 to 8 maund crop of American cotton in 1915-16, followed by berseem in the same season which did well. The berseem was over by April-May, and the wheat, the subject of the investigation, was sown in the following October-November. The essence of the treatment * was the tillage operations during the intervening period. This was a consequence of the experience the writer gained in the wheat tracts of the Bombay Presidency, where the crop is solely dependent upon the rainfall which falls in the preceding monsoon and where good crops of wheat can only be obtained by the most careful conservation of this rain water by suitable tillage work given at intervals during the monsoon period. Thus in the Broach District, where the blade-harrow is a very suitable implement for the class of soil to be dealt with, the land may be harrowed as often as 15 times from July to October. At Mirpurkhas the tillage operations were spread over the period from the end ot July to the beginning of November, and as the monsoon rainfall is very limited one irrigation was given in the month of July to facilitate ploughing. In August-September there were 4 or 5 inches of rain, and the land received

* The land had been carefully levelled and canalized in a previous year.

a double irrigation in the latter half of October preparatory to sowing the seed in early November. The tillage treatment to the whole area was similar to that given to plot IX-3 which is summarized below :—

Ploughed with Egyptian plough	30th July
„ „ Monsoon „	14th August
„ „ Sabul „	4th October
„ „ Rajah „	22nd October

After each ploughing the land was *sammared* with the " plank " or rolled with the clod-crusher, whilst the blade-harrow was also used as found necessary. Pissi wheat was drilled on the 4th November with the Jalgaon three-coultered drill. Subsequently the crop received one irrigation in the month of January. The yield was $23\frac{2}{3}$ maunds (1,894 lb.) of grain per acre the plot being $1\frac{1}{2}$ acres in area. An adjoining plot treated similarly, save in one important respect (*viz.*, no irrigation was applied during the growing period), yielded an outturn of over 19 maunds (1,533 lb.) per acre. These two plots occupied a site where the soil is of a stiff-working character and where under local Sindhi methods four or more waterings would have been applied to the standing crop. Other comparative results are summarized in the following statement, the treatment being as described above.

Name of wheat	Area in acres	Yield of grain in lb. per acre		Series	Plot	Remarks
		One watering	No watering			
Pusa 12	The comparisons were made on half plots measuring from 1 to $1\frac{1}{4}$ acres per plot.	1,333	1,172	VIII	3	Soil somewhat stiff.
Pissi		2,048	1,533	IX	2	
Pusa 12		1,116	970	XIII	1	Light free-working soil.
Pusa 12		1,600	1,680	XIII	2	
Pusa 12		1,418	2,062	XIII	3	
Pusa 12		1,718	1,633	XIII	4	
Pusa 12		1,067	1,333	XIII	5	

Growing wheat without irrigation to the standing crop is a well-known practice in many parts of Sind where it is known as *bosi* cultivation, but there is no such practice on the Jamrao area which in the opinion of the zemindars is not a *bosi* tract. Under the circumstances the results noted above are of much interest and importance. The conclusion, however, should not be drawn that the *bosi* system should be introduced on the Jamrao. This system

demands a soil possessing good texture and strong capillary powers, although good tillage does neutralize to a great extent the unsuitability of stiff-working soils for this system of cultivation. The object of this paper is to indicate the extent to which the irrigation applied to standing crops can be reduced without detriment to yields, which on the contrary are benefited by the restriction, owing to the lessened damage to soil texture and consequent reduced interference with proper soil-aeration and ventilation. On the Jamrao area, where the soils are to a large extent stiff-working, probably two irrigations judiciously given to the standing crop would secure maximum outturns, provided due attention be paid to preliminary tillage. These figures bring out the differing demands for water made by soil types. In the case of Series XIII the land consists of a free-working soil, and the outturns indicate that such a soil is almost independent of irrigation to the standing crop. Series VIII and IX on the other hand have a somewhat stiff soil, which soon dries out after irrigation and has little power of replenishment from below owing apparently to weak capillary action. Such a soil responds to a single irrigation by an increase of yield amounting to 30 per cent. in the case of plot IX-2.

One additional factor influencing the results obtained in this investigation remains to be mentioned, and that is the breaking up of the crust which forms on the surface after each irrigation by means of a suitable implement such as the Canadian spiked harrow. This harrow was used in the case under consideration and was found most useful in producing a soil mulch on these plots where the soil was free-working and free from *kalar*. Where, however, the soil was stiff and more or less impregnated with *kalar* salts, this implement could be used with only a limited amount of success because such soils possess the characteristic of drying on the surface very rapidly as soon as the irrigation water has disappeared and then the surface of the land bakes very hard. In short the interval between being too wet and too dry for harrowing is so brief that in practice it is difficult to make use of such harrows which tend merely to scarify the surface and not to stir the soil.

In conclusion, the results secured, with one irrigation to the standing crop, with the principal wheats sown in this investigation will be found in the following statement, where it will be found that good outturns have been obtained with each variety grown on a scale of several acres. In considering these yields it should be borne in mind that the average yield of wheat on the Jamrao canal is about 8 maunds (640 lb.) of grain per acre and that too after the land has rested for one or two seasons.

Name of variety	Area sown in acres	YIELD PER ACRE IN LB.		Series	Plot	REMARKS
		Grain	Straw and chaff			
Pusa 12 (home seed)	4	1,239	1,713	VIII	1, 2 and 3	Soil rather stiff.
Pissi (home seed)	5	1,733	1,609	IX	1, 2 and 3	do.
Punjab 11 (Lyallpur seed)	3	1,240	1,690	X	3 and 4	do.
Pissi (3 acres home seed and 4 acres Hoshangabad seed)	7	1,147	1,661	XII	1, 2, 3, 4 and 5	Some *kalar* in plots.
* Pusa 12 (mostly home seed)	$6\frac{3}{4}$	1,460	1,611	XIII	1, 2, 3, 4 and 5	Soil light and free-working.
Pusa 12 (home seed)	2	1,341	2,245	XIV	1, 2 and 3	do.

* Plot XIII-5 was sown with seed received from Cawnpore, but it contained *kalar* and the outturn fell short of 14 maunds per acre or 1,120 lb.

MANURING OF *HEVEA BRASILIENSIS.*

BY

RUDOLPH D. ANSTEAD, M.A.,

Deputy Director of Agriculture, Planting Districts, Bangalore.

Hevea rubber is unique among crops. The crops which have been most studied as regards manures are grown for food, and for the plant reserve materials stored up in the fruit, grain, or root. In the case of rubber it is plant reserve of food which is wanted, it is true, but in the form of latex obtained by excising the bark. The yield of this latex even from the same tree is influenced by a number of different factors : the humidity of the air and the soil saturation, *i.e.*, the rainfall, have a marked effect, as also do the time of day at which tapping is done, the depth to which the bark is tapped, the area of bark removed and its position on the tree, the tapping system adopted, and even the tapper ; all these have an effect upon the yield. In addition to this the trees have a distinct individuality, so that it is not perhaps surprising to find that it is a difficult crop with which to conduct any kind of accurate manurial experiments.

The result of practically all such experiments so far conducted has been that the unmanured blocks give quite as good yields, if not better than the manured ones. Thus in Ceylon the manurial experiments, which have been carried out since 1913, gave results at the end of 1917, which showed that the yield from the unmanured control plots was still equal to the highest of the manured plots.

The same experience has been met with in South India. A series of manurial experiments were laid down on Kerala Estate in Malabar, in 1914, and have been most carefully conducted with a number of different manures. At the end of three years, in

June 1917, the plots which gave the highest yields were the unmanured plots, and moreover these unmanured plots steadily improved their position in order of merit as the experiment proceeded.

In Ceylon phosphoric acid gave the best results among the manured plots, and potash the worst, whilst nitrogen produced a large increase after the first application but fell off heavily after the second, and the general advice given in Ceylon as to manuring rubber is to bury the leaves, which fall from the trees which are deciduous, in shallow pits, eight feet long by six feet wide and nine inches deep, between the rows with basic slag and other phosphatic manures.

At Kerala the best results among the manured plots were obtained by the use of kainit and a mixture of basic slag and sulphate of potash. The fact remains, however, that in all these cases the unmanured plots are the best, and it may be considered whether the actual yield of latex is the best way to judge of the effects of manures. One would not perhaps expect manures to increase the actual latex flow or the rubber content of the latex, but rather to increase the girth of the tree which would ultimately mean increase of yield because there would be more bark to tap.

Some experiments conducted at the Kuala Lumpur Gardens in the Federated Malay States with young rubber, in which manures were applied every other year, showed that there was a stimulating effect on the growth of the trees which lasted for a year only. At the end of four years the total girth increases of the manured plots in every case were considerably more than those of the controls. At the end of the fourth year tapping was begun, and it was found that the unmanured plots gave the poorest yields of rubber, while the highest yields were obtained from those manured plots which gave the biggest girth increases, but this is only to be expected since increase of girth means a corresponding increase of length of tapping cut. To judge of the effects of the manure on the yield, apart from that shown by increase of girth, a comparison would have to be made of the yields per area of bark excised.

Increase of girth means ultimately increased yield of rubber, and to test the full value of this it would be necessary to compare

two blocks of rubber, the one manured and the other unmanured, and neither of them tapped before the experiment began but both tapped on the same system throughout a whole cycle of virgin bark excision and a first renewal excision. This would occupy a period of about 18 years, and it is quite possible that it is as yet too soon to try and deduce results from any manurial experiments with *Hevea* at present in existence.

Hevea is not alone in respect to giving negative results from manuring. In the 16th Report of the Woburn Experimental Fruit Farm it is pointed out that while on one of the farms excellent results have been obtained with manures, yet at Ridgemount farm continuous manuring of apple trees over a period of twenty years has produced a negative result, and a somewhat similar result was obtained in America. It may be that in the case of *Hevea* the soils on which the manurial experiments have been conducted are rich enough without the addition of fertilizers, but there are so many factors which influence the yield that it is a most difficult crop to experiment with. The individuality of the trees alone is a most important and disturbing factor, for it has been found in Ceylon that one tree in every ten gives outstanding results. The experimental error must therefore be very large, and very few experiments have been laid down in such a way as to enable the determination of this figure to be made. Attention may be drawn in this connection to a paper dealing with this subject by Bishop, Grantham, and Knapp in Sumatra published in the *India Rubber Journal*, dated 5th April, 1915, in which the authors point out that in dealing with rubber a probable error over a period of one year takes into account the effect of site upon the crop at a certain age and under conditions existing at that age only. Local site conditions may cause similar areas to alter their relative yields with increasing age in such a manner as to cause a variation in probable error among the same plots at different ages. Further, if the probable error is known for a series of ages for one set of conditions of planting, such as spacing, in a given site, this may be incorrect for other planting conditions in a similar site, and for the same planting conditions in a different site.

Wood and Stratton showed that the probable error for annual crops may be taken as five per cent. ; and the authors of this paper show by discussing certain experiments in Sumatra that the probable error for rubber will not be greater than seven and a half per cent. in carefully selected plots, each containing at least 100 trees, but the minimum size of plot necessary for accurate experiments may prove to be several acres. Very few experiments devised to test the value of different manures for *Hevea* have been laid down in such a way that the probable error can be calculated.

Yet another factor must be taken into consideration in all manurial experiments with *Hevea*, and that is the distance apart at which the trees are planted, and it may well be that this is the determining factor and of such importance that it swamps all others and renders results meaningless. Thus in the experiments carried out at Kerala, already mentioned, the manured plots showed very little increase in girth of the trees over the unmanured plots, which looks as if the manures only forced the trees upwards and that the spacing factor overruled all others.

In South India at any rate the majority of the rubber is planted far too closely, and a process of thinning out is being carried out on most estates. This thinning out is, however, as a rule left until too late, and the trees are allowed to remain crowded until the damage is done—the crowns are interlocked, and the stems have been forced upwards instead of girthing out. Thinning out should undoubtedly be commenced as soon as the branches of the trees begin to touch, that is in many cases by the time they are four years old, and should be carefully and thoughtfully continued every year after this age till they reach their final spacing which appears as if it would be 80 trees to the acre or even fewer.

The influence that spacing has upon the yield is shown by the results obtained where thinning out has been done. Thus in some experiments in Java, three fields, planted 12 feet by 24 feet, were thinned out to 24 feet by 24 feet by removing alternate rows of trees. Though by this treatment half the trees had been removed, the yield showed no decrease. The average production per field and per tapping day during the three months preceding thinning

out had been 4·28 lb., and that during the three months following the operation was 4·12 lb., whilst the figures for the three control fields which were unthinned for the same periods were 3·33 lb. and 3·17 lb. The decrease in yield was the same in both cases and cannot be attributed to the thinning out.

Such a result as this would mask any effects of manures, and for this reason a spacing experiment has been laid down in Malabar this year to determine the optimum distance at which this crop should be planted. Rows have been planted from the beginning at distances of 40 feet, 35 feet, 30 feet, 25 feet, and 20 feet, and it is hoped, when the optimum spacing has been determined, to convert the experiment ultimately into a manurial one. The advantages of original close planting with subsequent thinning out, the importance and value of individual trees when they are widely spaced, and the loss caused by diseases have not here been considered, but only the effect of the spacing.

Despite the difficulty of proving the benefit of manures to rubber it is generally agreed that there is a benefit. Any manure which increases the foliage of the tree, its rate of growth, or its bark renewal, must have a beneficial influence on the health of the tree and favourably affect its yield. Some of the most successful results in South India in manuring rubber have been obtained from the use of lime. In some recent experiments lime gave 2·15 lb. of made rubber per tree, and lime followed by manure 2·44 lb., as compared with the unmanured and unlimed yield of 2·34 lb. per tree. In another experiment lime gave 2·37 lb. per tree as compared with 2·05 lb. per tree obtained by an application of nitrate of soda.

On one estate situated on a laterite soil a definite system of manuring has been adopted since the trees were a year old, consisting of applying annually a dressing of ten cwt. of slaked lime per acre, broadcasted and forked in, while at the same time a heavy crop of *Crotalaria striata* has been maintained as a green dressing, and regularly cut and buried. This has at the same time stopped wash as well as supplied organic material so much needed by this class of soil. This has been done for four years, and, though there are no control plots with which to compare it, the system having

been adopted as a regular estate practice over the whole area, the growth of the rubber is exceedingly good, the colour of the foliage is very dark green, and the trees when brought into tapping gave a yield which compares very favourably with trees of a similar age on a richer class of soil, and exceeded expectations.

It will generally be found that if two estates are compared, the one manured and the other unmanured, the latter will, over a period of years, give a smaller yield per acre than the former. The unmanured trees also very often have a yellow look about the foliage, while the manured ones have very dark green leaves, a difference which is very marked when the fields are viewed from a distance, and a good healthy tree as a rule yields more rubber than a sickly one, though this may be difficult to prove.

In conclusion, it would appear that what is required is for agricultural stations interested in this subject to lay down an entirely fresh set of experiments with *Hevea*, designed from the first to test the influence of manures on trees widely spaced from the start, and on trees thinned out early. Such experiments should be so designed that the experimental error can be calculated, and a working plan drawn up to ensure that one system of tapping is adopted throughout the whole course of the experiment. When this is done more light will be thrown on a subject which at present is somewhat obscure and puzzling.

FUNGI AND DISEASE IN PLANTS: A REVIEW.*

BY

G. A. GAMMIE, F.L.S.,

Imperial Cotton Specialist.

THE author and publishers deserve commendation for the care they have taken in the production of this book. It is of handy size and weight, it opens easily and remains flat when wanted, the paper is good and flexible, and the print and illustrations are very clear. For the future it will serve as a model of what scientific publications should be in this country.

In his preface, Dr. Butler tells us of the inception of this book and its purpose. Its publication has been delayed in the first instance, because India being a large country with a diversity of climatic conditions, soils and crops, much preliminary labour had to be expended before the 200 diseases of crops, which are treated herein, could be practically studied in the field and laboratory. The damage caused to crops by fungi is so great that one of the chief desiderata of Indian agricultural activity is to develop means of reducing it, and the author has succeeded in his endeavour to make us realize how much knowledge has to be acquired before even a simple disease can be dealt with confidently. Such diseases as smut in *jowar* (*A. Sorghum*) and rust in wheat, taking two instances only, cost the country millions of rupees annually, and this book has succeeded in making us realize how much knowledge has to be laboriously acquired before even the simplest disease can be treated

* Fungi and Disease in Plants, by E. J. Butler, M.B., F.L.S., Imperial Mycologist, Agricultural Research Institute, Pusa. (Calcutta: Thacker, Spink & Co., 1918.) Price Rs. 15.

with confidence in the result, and the preventive methods evolved in recent years must have already saved the country enormous sums of money. The comparatively small outlay incurred in the study of plant diseases, with a view to their mitigation or cure, has already been returned to the country with manifold interest.

Part I of the book is devoted to the explanation of the Natural History of Fungi generally. The first chapter deals with their nature, structure, growth, reproduction, dissemination and the most recent system of their classification. We are taught that fungi are quite as much plants as our trees, shrubs and herbs, and that their importance is unfortunately quite out of proportion to their size, which is measured by the micron (μ), this being the one thousandth part of a millimeter, or the one-twentyfive-thousandth part of an inch. Although infinitely minute in their parts they are potentially great, and this fact is testified in many and diverse ways by the awful ravages they perpetrate throughout the animal and vegetable kingdoms. It is necessary to bear in mind that, on account of their structure, they are unable to build up their food as other plants do, so they have to provide themselves with that already prepared in the bodies of plants and animals, and it is in this process that they cause injury if not death to their hosts. The spread of fungi is assisted by the dispersal of their vegetative parts or by their minute spores. The first method may be attributed to many causes—for instance, the infection in many cases can remain in the soil in readiness to seize on a succeeding crop, or it may be carried on by parts lying dormant in seeds or other sources of reproduction, and these can be scattered widely even throughout the world by the agency of mankind through ignorance of the dangers involved, and the lack of expert knowledge and guidance which nowadays, however, is invoked in most civilized countries.

The second chapter discusses the food of fungi and the reasons why they have to prey on vegetable and animal organisms to obtain their food. Plants which possess green organs, such as leaves, can build up the food they require out of the carbon dioxide of the air and certain substances derived in solution from the soil; but fungi, being like animals devoid of this power, must also feed like them, that

is, they must utilize the food materials already prepared by plants and animals. According to the manner in which fungi obtain their organic food, they are divided into two great classes: Saprophytes, existing on dead animal and vegetable matter and by hastening its decay ridding the earth of useless encumbrance; and Parasites, which attack living tissues and cause disease, and it is to the consideration of the second class that the attention of the practical man is directed, at least so far as regards agriculture or horticulture. In a small series of fungi, the parasitism instead of being injurious to the host is distinctly beneficial. This condition of dependence between them is known as *Symbiosis*. The association of a fungus and an alga to form the organism called a lichen is an extreme example. A large number of plants form associations between the tissues of their roots and fungi.

The third chapter details the life-history of parasitic fungi, and the information under the heading of Infection should be carefully read.

The fourth chapter defines disease, its diagnosis, symptoms and morbid anatomy.

The fifth enunciates the principles of the control of plant diseases. For the proper carrying out of this, knowledge is required of the cause of the disease, of the life-history of the parasite, and of the circumstances which influence the establishment of parasitic relations between it and the host. In other words, a thorough understanding of all the contents of the preceding chapters in this book is necessary, and in addition to this the whole history of each and every parasite must be worked out in full, and as so little had been done along this line of research in India before the author took the task in hand, we can quite appreciate the amount of labour he has devoted to the working out of 200 specific instances.

Disease may be avoided by the use of more resistant or earlier varieties, by proper rotations, by seed and soil disinfection, or by the use of substances used as sprays or otherwise. The subject is vitally important, and the book should be carefully studied on this point.

The second part of the book is devoted to the special description and treatment of each disease which affects many cultivated plants

in India, and first in importance come the rusts of wheat. which by their total effects cause more damage than any other crop disease in the country. It is pointed out that there is no direct treatment against rust, but as recent researches have proved that resistance to it is a Mendelian character, there is a possibility that hybridization, with a view to produce resistant varieties, may lead to results of the utmost value. A certain amount of success in several countries has already been attained by this method. In addition to the rusts, other diseases of wheat are described. In oats, smuts rank as the most destructive of crops in temperate countries, the loss in the United States of America alone being estimated at £3,000,000 annually.

In *jowar*, the grain smut is perhaps the most destructive disease due to a smut in this country. A solution of copper sulphate is a very satisfactory disinfectant of the seed before sowing, and it has come into use widely for this purpose by the Indian farmer, who has thus learned his first lesson in plant disinfection and has applied it in practice.

In pulse crops, wilt is perhaps the most destructive of the diseases described. In vegetables, root crops and oil-seeds, we have, amongst many others, the ring disease and blight of potatoes, both very virulent, and in cruciferous vegetables there are white rust, mildew and blight.

Dye, drug and spice plants also have their special diseases.

Sugarcane is subject to a variety of diseases, of which red rot is the most serious in India.

In plantation crops tea has quite a formidable list of enemies, and the leaf disease of coffee devastated that crop in Ceylon and other countries. Rubber trees are also found to suffer from many diseases.

The bibliography arranged on the scheme of this book is particularly full and will be of the utmost value as a guide to those who wish to collect the literature on fungi, especially in its relation to India. The index is complete, and many of its items serve admirably as short abstracts of the information contained in the book.

This book has amply fulfilled the purpose for which it was written. To those who have the desire to learn, it will teach many lessons, the following among many others: the possibility of the introduction of new diseases through ignorance or thoughtlessness should be guarded against by organized methods of control; that prevention is better than cure and disease should not be allowed to spread; and that the public attitude towards plant diseases need not be one of patient resignation, but of active warfare against them.

Another line of study is now open to amateurs who did much or nearly all in India for Natural History in the years that have gone, and this will be a valued hand-book by farmers, planters and the many more who would gladly fight against disease in their plants if they only knew how it is done. A wide field has been thrown open to the earnest student who wishes to take up lines of work which will not only enable him to pass his leisure hours in pleasure, but, if he follows the proper lines, to forward the well-being of his country.

We are all under deep obligation to Dr. Butler for the task he has accomplished so ably, and we look forward to his promised instalment of still another volume dealing with the diseases of fruit and forest trees and of many garden crops.

THE SPREAD OF CO-OPERATION IN THE PUNJAB, II.

BY

C. F. STRICKLAND, B.A., I.C.S.,

On Special Duty in the Office of Registrar of Co-operative Societies, Punjab.

(Concluded from vol. XIII, pt. II, p. 271.)

V. THE ATTITUDE OF OFFICIALS.

OWING to the ingrained tendency of the Indian peasant to expect every important movement to bear the sanction of, and be actively initiated by, Government, together with his bigoted distrust of every novelty that is in practice so sanctioned and introduced, a certain measure of support from local officials is indispensable when co-operative work is opened in a new area. The published or secret hostility of the money-lender, the suspicions and jealousy of the powerful acquisitive landowners, the ignorance and apathy of the indebted, must be counterbalanced by the moral weight of official patronage. While societies in the Punjab were few and struggling, they were promoted or encouraged by Deputy Commissioners and Revenue Assistants. In 1906 the Financial Commissioner was of opinion that societies would always be few and could be managed by the district authorities ! The rapid multiplication of societies in Gurdaspur was in the beginning more directly due to official action than in the rival district of Jullundur : and here, as always, the consequence of unnatural forcing was an unhealthiness which at one stage resulted in many failures. The direct participation of Tahsildars* may be described as almost universally harmful; the zemindar is quite unable to dissociate the Tahsildar from

* Subordinate district revenue officers.

his chaprasi* and from the various thoughts evoked by that satellite. Even as late as 1916 the misguided energies of a Tahsildar provoked with reason a general alarm and resentment in his jurisdiction.

It is, therefore, very rarely that a District Officer is asked for assistance, and then only to avoid a scandal which will react on the whole district. Many of the earliest societies were founded by *zaildars*† at the Deputy Commissioner's suggestion; but when he was unable to continue his attention, such societies usually became lax. If, however, a *zaildar* or any man of position is concerned, whose imprisonment for a criminal offence or a civil debt might inconvenience the administration, it is not uncommon to ask a Deputy Commissioner whether he wishes to intervene in the public interest. A Deputy Commissioner or Sub-Divisional Officer is *ex-officio* president of most central banks : in the weaker banks they are invited to take a large and educative share in the control ; in mature banks they allow the authority to pass more and more into the hands of unofficial vice-presidents and secretaries.

The principal aid now desired from Deputy Commissioners and other officials is a public display of interest and sympathy : the stimulus of a high official's support is valuable, but his disapproval or inferred hostility brings the societies of a flourishing district into chaos in two years.

Revenue officials or Judges are seldom now openly unfavourable ; in the beginning there were a few cases of strong opposition. The Munsiffs,‡ despite all that the zemindar has to say against them, do in the majority of cases show patience and goodwill towards zemindar co-operators who are crass and impatient; and this attitude is not confined to Munsiffs from the agricultural classes. The less friendly minority of the judiciary are unfailing in ingenuity. A curious and perverted tendency is sometimes noticed to give decrees without instalments against a co-operator, on the ground that his society can lend him the money to pay at once !

---

* An orderly.

† Landholders of position who assist revenue and other officers in local administration.

‡ Civil judges of the lowest rank.

Lastly, no man can exercise more influence than the humble patwari.* Patwaris of all tribes and castes may be found encouraging and preaching co-operation: a few are permitted to work as secretaries if consistent with their revenue duties. Patwari secretaries are not employed where other agency is available, since, in addition to the natural misunderstanding caused in the zemindars' minds as to the Government's connection with the society, the transfer of an efficient patwari-scribe leaves a gap which no imperfectly-literate zemindar has courage or energy to fill; and such societies not infrequently collapse. Overt opposition by patwaris when found is suppressed by all Deputy Commissioners and most of their subordinates.

VI. The Staff.

The co-operative movement has been developed to large dimensions in the province "in a fit of absence of mind." The Registrar of 1905 received a Personal Assistant on Rs. 100 (equivalent to a present-day Inspector) and one clerk. This modest equipment was increased not inadequately, at least for outdoor duties, up to 1911; but from that year began the great leap forward, and the necessity for an appropriate addition of supervising power was perhaps not fully realized. The subjoined table will show the staff at the Registrar's disposal in each year, and its relation to the societies of all kinds requiring inspection.

Year	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917
Gazetted Assistants	..		$\frac{1}{3}$	.		...	$\frac{1}{3}$	$\frac{1}{2}$	1	$1\frac{1}{2}$	$1\frac{2}{3}$	$2\frac{1}{2}$	$2\frac{1}{2}$
Inspectors ...	1	1	1	3	5	6	8	8	7	9	13	14	19
Sub-Inspectors...	..	.	...	...	.	4	8	15	30	40	63	67	75
Societies ...	12	24	177	258	316	706	1,093	1,769	2,845	3,333	3,334	3,391	3,495
Average Inspector's charge	12	24	177	86	63	118	137	221	406	370	256	242	184

* A village revenue officer.

From this statement it is evident that from 1912 onwards the teaching and auditing agency was seriously in defect, since Government, which had hitherto supplied both Inspectors and Sub-Inspectors at the public cost, ceased to meet the need in proportion to its growth, and the urgency of the question was not brought to the notice of Government as emphatically as was advisable. The standard recently laid down by the Committee on Co-operation, 1,000 societies to a Gazetted Officer, and 200 societies to an Inspector, was maintained until 1911; but from 1913 onwards the usual charge of an Inspector was higher than the average shown in the table, since an Industrial Inspector from 1914, and an Inspector for Muzaffargarh in 1916, were appointed to create societies in their respective spheres without relieving the ordinary workers. The Registrar himself has been Registrar of Insurance and Joint Stock Companies from 1912, and by successive blows during the war has been appointed Controller of Hostile Trading Concerns, Custodian of Enemy Property, Receiver of Claims for Property in the Enemy's Possession, and Liquidator of Hostile Firms. His task was further complicated by the evil of fraudulent Shadi Funds* and by the financial crisis of 1913-14, the latter producing at one time a situation which frankly left him no time whatever for co-operation. Progress being at this period extremely rapid, and supervision inevitably reduced when it should have been most close, defects and even grave irregularities multiplied in the societies, and all or nearly all the troubles with which the re-organization following on the Committee's report has had to cope, may be ascribed to the insufficiency of supervision and inspection. Four Inspectors were added in 1915 from the Contribution Fund of Societies, and the cost of numerous Sub-Inspectors was wholly or partially defrayed by affluent societies, central banks, and District Boards; finally, in 1917 Government accepting the Committee's standard of 200 societies as the normal circle, undertook the charge of all Inspectors, while all Sub-Inspectors are in future to be paid from co-operative funds and are subject to the joint authority of the Registrar and the various financing bodies. It

* Marriage insurance funds.

has been ruled that the entertainment of a Sub-Inspector from District Board funds is not desirable : there is, however, no objection to a contribution being made by a Board towards his salary, as an English County Council under the Small Holdings Act may contribute to support a co-operative agency. Central Banks, Unions, and Societies paid 6 Sub-Inspectors in 1912, 20 in 1913, 24 in 1914 : a system was then instituted by which every society contributes (up to a limit of Rs. 50) 5 per cent. of its annual profits to a fund which amounted to Rs. 27,600 in 1915, and Rs. 35,600 in 1916; the estimate for 1917 is Rs. 39,915. The cost of Government staff in 1916, excluding the Registrar and his two Assistants with full powers, was Rs. 38,750.

It is instructive to note that, as shown by the annual report for 1915-16, the Central Provinces with 2,685 societies had 3 officers of superior grade to assist the Registrar, and 22 Inspectors ; the United Provinces had, in addition to the Registrar, 2⅔ Joint or Assistant Registrars and 12 Inspectors (an obviously inadequate number) for 3,189 societies ; while in Burma the Registrar was supported by 1½ full-power Registrars, 3 Assistants, and 15 Inspectors for only 2,251 societies : yet the annual report of that province declares the staff to be overworked.

The services of honorary helpers have varied in value ; for the purpose of creating enthusiasm and assisting recoveries of debts, many of them are superior to any paid agent; but their literary skill and accuracy is seldom equal to the technical task of keeping the registers in good order, and they are not entrusted with the duty of annual audit. Some are valueless and do nothing : these are being weeded out.

It has been resolved in future to recruit Inspectors from three sources : a few Naib Tahsildars* or other Government servants will be placed on deputation ; a reasonable proportion of Sub-Inspectors will receive promotion when their efficiency is proved ; the rest will be selected by direct appointment from graduates of the agricultural classes. Government servants will be trained for three months :

* Assistant Tahsildars.

the directly-appointed graduates will work for a year beyond that period as Sub-Inspectors. The inconvenience of arranging the pay and allowances of Government servants on foreign service, particularly in officiating vacancies, their tendency to use over-forcible methods of persuasion, and their natural desire to return to their former employments when promotion offers, render it probable that this system of borrowing on deputation will be sparingly used. Such reversion, however, accelerates promotion for others, while the authority claimed and exercised by a naib-tahsildar Inspector may be effectual in redeeming from grave trouble a disordered society. Promoted Sub-Inspectors often lack education and the power to assimilate co-operative literature; they have a valuable background of experience and are *ex hypothesi* efficient and hardworking. Graduates may lack knowledge of the world and of men, but are readier to examine and grasp the principles underlying their work.

Sub-Inspectors are now seldom taken unless matriculated: their quality is steadily improving.

Some of the most successful workers have been of the money-lending or non-agricultural classes: they are good economists and hardworking, but the prejudices of the zemindar, whether sound or groundless, militate against their popularity.

There are no merely supervising Unions in the Punjab, and the devolution of authority over the work of Sub-Inspectors, which is slowly and cautiously proceeding, will be in favour of central banks. The office staff is and has for some time been inadequate: a recent appeal for bread having evoked a sample of war diet, there are at present a Head Clerk and 7 Assistants, the pay of the latter ranging from Rs. 80 to Rs. 25.

VII. Financial Control.

In the earliest stages, direct pecuniary assistance was afforded by Government to primary societies: some of the latter inspiring confidence in the public and attracting large deposits from non-members, began to lend to weaker associations: the need for outside capital was felt with increasing urgency, and the lending primary societies were found to have neither the business training nor (in

some cases) the breadth of view to manage adequately and without confusion the large operations which resulted. In February 1909 was founded the Jullundur Central Bank, followed by 5 others in 1910: at the close of the year 1916-17 there were 23. In all cases these banks were founded by individual shareholders; but primary societies and Unions are now required or encouraged to buy shares, and are given special representation on the Managing Committee.

The first Union in the Punjab commenced work in 1910: there are now 18 of which 9 are in Gurdaspur and 5 in Hoshiarpur District. One in another district is being informally closed, and it is not unlikely that the process of gradual elimination may continue. These bodies have not generally proved themselves to possess corporate vitality, and their working motive is sometimes a desire to obtain increased funds by deposits or a guaranteed loan, and sometimes the honourable but personal ambition of an individual. At a certain stage the Unions and the large lending societies began to compete seriously with Central Banks; but societies are now expected to deposit surplus funds in the central bank at rates higher than those allowed to the public. As a rule, Unions in the Punjab do not perform efficient audit work, and this duty will be increasingly undertaken by auditors controlled by the central banks, the latter becoming at the same time more unofficial and independent.

The system of cash credits to well-managed societies has only recently been introduced: there is no reason why it should not work as well in this province as elsewhere if the managing committee of the bank will maintain a watchful control over borrowers. For this purpose they receive the annual inspection reports of the auditing Sub-Inspector, and can examine the entries made by the Registrar or his Assistants in the Village Card, a statement showing at a glance the condition and class of the society, and fixing its cash credit or maximum loan. It is proposed that every society shall fix in general meeting the maximum liability which it will incur in the coming year, the maximum loan being then laid down by authority at a sum not exceeding such liability and often markedly lower: but the actual working of this proposal is at present not fully

understood in the villages. A number of Central Banks and Unions have obtained cash credits from the Bank of Bengal, amounting in 1917 to between 9 and 10 lakhs : but, as required by the charter of that bank, such credits must be guaranteed by individuals; and though public-spirited co-operators have not failed to lend their security, it is in every way desirable to relieve them of the burden when the co-operative movement obtains a higher financial reputation in the market. The Bank of Allahabad has with wise foresight granted a cash credit to the Lyallpur Central Bank on the security of deposited village societies' bonds, and an extension of the system may be possible. The need for a Provincial Bank has not hitherto been pressing : loans are from time to time made by one bank to another with the Registrar's sanction. A scheme for a Provincial Union is under consideration, which will receive deposits from banks embarrassed by a surplus and lend to others which require funds : such a Union should be able to borrow in the open market at moderate rates, but the difficulty of disposing of a general surplus has not been solved. The Union will also establish a provident fund for Sub-Inspectors and other employees who are not Government servants, and will manage the 5 per cent. Contribution Fund on a provincial basis. It would handle more economically than small societies can do the reserve funds of its members, which are at present invested often in comparatively trifling amounts in Government stock or deposited in a joint stock bank.

Wherever practicable, future central banks will be set up chiefly or entirely by shareholding societies, the individual element being reduced to a minimum or excluded altogether. The only central industrial body—the Weavers' Central Co-operative Stores, Limited, of Lahore—which is already working without registration under official management, is being organized in this way by weavers' societies with an individual president. It will operate as a central bank for weavers' societies.

VIII. Attitude of the Public.

The outside world has, on the whole, been slow to realize the advantages of a co-operative society for purposes of investment.

In 1916 primary societies held 10½ lakhs of deposits from members and 14 lakhs from non-members, representing a percentage of 7 and 10 per cent. of their working capital. But the large bulk of this is held by a comparatively small number of societies, and nearly half of it in one district, usually as the result of public confidence in some outstanding man who is the moving spirit: other societies attract little or nothing. This failure may be attributed partly to ignorance and ancient suspicion in the minds of the well-to-do, partly to hostility of the money-lender and trader, and in some districts to the wealthy Muhammadan's dislike of an institution dealing in interest. Owing to fluctuation in crops there cannot be an entire certainty that village societies will repay deposits when due, above all since the zemindar-depositor needs his money particularly in those seasons of scarcity when repayments in societies are lowest: in well-managed societies the difficulty can be met by a loan from a central bank, but less successful societies are now only allowed to receive deposits from non-members with sanction. The confidence placed by the public in some leading co-operators is attested by the fact that during the bank crisis of 1913 deposits were withdrawn from central banks and placed in the village societies managed by these persons. That crisis caused a certain withdrawal from central banks, but the balance was soon restored, and during the present year many central banks of the Punjab, prior to the issue of the War Loan, were overflowing with deposits from all classes of the community, and a surplus is now again almost universal. The outbreak of war caused no panic, although Central Banks are to some extent regarded as Government institutions.

Except in the Western Punjab, individual shareholders in good central banks are easily obtained, and the shares of several institutions were selling at a premium until the issue of new shares to individuals was recently discontinued as superfluous. In the Western Punjab considerable misunderstanding still prevails: zemindars lack business understanding and regard their share payments as an irrecoverable subscription: there is some objection to receiving interest, and an unfavourable influence was exercised by the

fraudulent "registered" Shadi Funds. Not infrequently the more prosperous landowner regards the co-operative movement with dislike, as depriving him of his opportunity to buy the lands of depressed neighbours; but much excellent and public-spirited work has been done by *zaildars* and other men of good position, often without the instigation and encouragement of District Officers.

The *baniya** is generally hostile, and his sentiments occasionally prove to be inherited by his offspring in high office. Overt partiality which can be reported to superior authority is rare. The village money-lender loses no opportunity of misrepresenting the purposes and effects of a society when its foundation is proposed, and of corrupting the allegiance of weak members subsequently. As a deterrent, however, he sometimes cuts off all loans of men who join the society, thereby performing an invaluable service to the co-operator: the difficulty of overcoming the *baniya* is far greater where he continues to lend. Money-lenders who become shareholders or depositors in village societies are actuated by various motives: a real disinterested appreciation of the movement, an anxiety to conciliate powerful zemindars, a desire to recover an apparently bad debt by transferring it as a nominal deposit to the society of which the debtor is a member, or even a dark plan to upset the society by insisting on repayment due at a time when crops have failed. Enmity is keenest in the Eastern Punjab, where applications for security to keep the peace are not uncommon. The Press, especially the vernacular, is singularly apathetic towards a movement which beyond all others contributes to the making of a nation. A certain attention was paid to the subject, and support given, by the *Zemindar* in its earlier and non-political days. It would not be too much to say that the European community, with the exception of those officials whose duties have introduced them to the question, has no knowledge of co-operation at all, although Central Banks offer them opportunities for permanent or temporary investment which can hardly be equalled.

* Professional money-lender.

IX. The Present Punjab Society.

The evolution of the prevailing Punjab type has been described. As now existing, it shows the signs of former mistakes and struggles, and the indications of a higher standard to be eventually attained. The working area has still in some cases to be reduced : loans to non-members have been almost stamped out : the necessity for interlending by primary societies has been removed by the creation of secondary bodies; but selfishness on the part of Committee members is not rare : inactivity or ignorance among the other shareholders allows the leaders to monopolize the funds. Insolvency is a growing evil, and is often the device of a defaulter when hard pressed : it is usually fraudulent. Remedy is now sought by requiring sureties for loans, by estimating each member's credit and fixing his maximum loan. A persistent trouble is that of fictitious repayments, the bond being merely renewed. Teaching and inspection will fight this down : but a clever Secretary can defeat all but the most searching enquiries. Hitherto the defects have been in many instances encouraged or overlooked by an imperfectly trained staff. Liquid resources are becoming available in all sound societies after their first probationary term by the formation of reserve funds in deposit, or by the grant of a cash credit from a central bank.

The most striking failure is that of credit societies to manage shops : it was anticipated that the ground would be cut from under the money-lenders' feet, and many zemindars' shops were founded by individuals or societies, especially in the Canal Colonies : they have failed almost without exception through lack of supervision and business habits. Weavers' shops, which take over the finished product for sale, wherever adequately inspected from the beginning, are in a flourishing position. Agricultural machinery of improved patterns was bought by societies from time to time, but where it was bought for common use, petty quarrels or conservatism hindered its profitable employment. Here again supervision was lacking, and the new method of stocking implements as agents for private sale avoids dangers and is acquiring popularity. There

is a brighter side to the picture. The peasant can now hold up his grain when prices are low, and is not compelled to sell at middlemen's prices in order to meet the revenue demand. Improved seed and improved implements are placed within his reach: continual instruction and argument at his housedoor by his wiser brother or his co-operative guides at last bring the light of better economy and better farming even to the rude and illiterate. There has been a general reduction of interest, both in the credit society and outside. While money is rendered obtainable on fairer terms, the zemindar is for the first time in his history taught—and has begun to understand—that swelling debt is not inevitable: he learns punctuality in payment, and discovers what it costs him annually to remain in debt. In many areas litigation, though stimulated at first by the process of redeeming lands and clearing *baniyas'* debt, is gradually and noticeably reduced. In order to understand simple accounts the villager sends his son to school, an unprofitable expenditure when the accounts were in Hindi character and in a series of faked *bahis* (account books). The proved facility of co-operation for credit, and the obvious danger of allowing money to be wasted on quarrels, have sown the seed of concord: and it is not unfrequent for a village society on inspection to recite with pride that there has been no faction and no criminal offence in the village during the year. It is not impossible that the society's *panchayat** may form a basis for a *panchayat* with wider powers; but this step forward can only be taken when the economic functions of a society are being carried out with entire success. Lastly, the surface of India's hoarded wealth has been lightly touched, and buried rupees have been dug up for deposit. But more valuable than this would be the prevention of further hoarding, an end not yet attained: the portable sovereign has replaced the rupee, and there has been proof in the last few years that the zemindar and even the co-operator is not guiltless of its disappearance.

The purest Raiffeisen Society admits only the minimum of share money required by law: in the Punjab society owned capital

* Managing Committee.

of shares and profits forms a great part of the funds : in most of the older societies shares may be withdrawn after a term of years. Pure Raiffeisen Societies are being experimentally started. The Punjab peasant is slow to understand joint liability, and is with difficulty educated to regard the funds as his own : it has consequently been necessary to make him contribute them in person and to continue his effort of thrift year after year. A loan from a central bank is persistently described as "Government's money." It is probable that this mistake can be corrected by steady training. The disadvantage of the share-system is that profits are usually divisible at some time or other, and an unhealthy greed for dividends grows up, Sikhs being perhaps the least co-operative in this respect. Among such tribes a Raiffeisen Society with indivisible profits will be the safest form.

The Raiffeisen Society contained two committees—one for current business and the distribution and recovery of money, the other for supervision of this ordinary committee. It has not been found possible or advisable to constitute this second body in the Punjab, where membership is smaller, illiteracy more general, and jealousy more rife than in most European countries.

The German Societies of all types have always held aloof, as far as possible, from Government, complying only with legal requirements and asking no favours. The same policy has not been followed in India, where Government, though a bureaucracy, looks with less suspicion than that of Germany on movements of popular reform, and allows more scope for variety and freedom of development. While gladly accepting pecuniary help at first, and in special crises later, the Punjab co-operator is not enervated by excess of Government support, and has never failed to supply his own capital. Official control through Registrars and Inspectors will remain necessary for an indefinite period owing to the dangers due to ignorance and disunion, and the general failure to appreciate the close care required in dealing with the money of trustful lenders and depositors.

The object of the Raiffeisen Society is to provide small loans for short terms and productive purposes : such must continue to

be the Punjab ideal: but where a peasantry is so burdened with debt that the annual interest at ruinous rates exceeds his annual savings, there is often no alternative to clearing him of the load with a comparatively large loan: to ask him to apply for insolvency before admission is to weaken that very sense of responsibility and honesty which co-operation builds up. A member who receives a loan for other than everyday purposes should be of approved character and backed by sound sureties.

The moral element which underlies and gives value to the economic effort of co-operation is not forgotten: its influence is felt in an unseen permeation of the peasant's mind by the ideas of self-help, mutual help, and mutual control, while the same principles are inculcated by the staff, high and low, in a doctrine which becomes more openly spiritual and appeals less to material advantage as the members, shaking off their debts, become conscious of their independence, and treat themselves and each other as men and citizens rather than as rats fighting for an inadequate store of grain. Those who, after trial and warning, fail to rise are expelled: others on whom the light of the future dawns wash their hands of past folly and seek admission with a firmer resolution. It is not always the well-to-do or the literate members who set the best example. The understanding shown and effort put forth by menials and ragged labourers will shame a sluggish *lambardar* (village headman) to cordial help or to venomous opposition. But wherever co-operative teaching has been real and humbly given in a spirit of brotherhood rather than as a pronouncement of dogma from the cathedral chair, it does not fail to lead the Punjabi peasant, slowly but little by little, to a sturdier freedom and a cleaner life.

Selected Articles.

AFFORESTATION IN THE UNITED PROVINCES.*

E. BENSKIN,

Deputy Conservator of Forests, Afforestation Division, Eastern Circle, United Provinces.

THE sources of wealth and commercial development in these provinces are agriculture and forests, but very few people realize how dependent the former is on the latter. The general public has an idea that the jungles are places to avoid owing to the dangerous wild animals and fevers which they harbour. This paper is, therefore, intended to convert those persons to realize the physical and economic importance of the forests for the prosperity of the country.

PHYSICAL IMPORTANCE OF FORESTS.

A new country is invariably covered with dense forests, which are gradually cleared away by the first settlers to make room for agriculture and to improve the general salubrity of their surroundings. This process has continued through centuries with the development of almost every country, and the forests gradually have receded to those regions topographically unfit for agriculture, and even here they have often been destroyed by physical causes consequent on the wholesale clearance of forests elsewhere. Forests are Nature's means of dealing with the meteorological forces. It is

* Reprinted from *East and West*.

believed that all rain clouds are derived from the sea and are driven over the continent, where they deposit their moisture, becoming poorer in moisture content the further they travel inland, until they reach a point where they become exhausted. A forest air and soil is always far damper than outside, and the continuous transpiration of a forest creates a wet halo which serves to enrich the winds with moisture and enables them to precipitate further inland. The geographical position of forests is, therefore, of great importance.

Forests by means of their foliage, root system, and litter serve as a protection to the earth against erosion and the rapid run-off of water from the soil. In this way the rain water has time to soak into the substratum to enrich the springs and is a source of perennial water-supply to the rivers of the country. Forests are consequently of great physical importance on mountains and hills in checking the rapid wastage of water and for the prevention of floods causing the erosion of the country further downstream.

ECONOMIC IMPORTANCE OF FORESTS.

With regard to the economic importance of forests, this is appreciated to a great extent. The forests, excluding artificial groves of which there are considerable numbers, form, however, only about 8 per cent. of the whole area of the province against an estimated 20 per cent. considered necessary in more advanced countries for the industrial and domestic requirements of the country. The exceptionally high price of timber and the distance of the forests from the industrial centres are serious obstacles in the way of industrial progress in this country. The great war now raging has awakened the Empire to the national importance of the forests and forest conservancy. In Germany you will often see the forests stretching right into the industrial cities and providing the industries with raw material at their doors: these industries are so varied that it was estimated that before the war 3,000,000 persons depended on the forests, in some way or other, for their livelihood. It is scarcely necessary to remind the reader of the very large potentialities of the forests of these provinces which

are capable of supplying most of the commodities previously obtained from foreign sources. During the last two years the surplus revenue has been more than doubled as a result of the development of indigenous supply.

EFFECT OF DISFORESTMENT.

Having briefly outlined the physical and economic importance of forests to these provinces, we will go back to the changes effected by unregulated forest clearances in different parts of the world and in these provinces.

We know that the sands of the Sahara and Arabia now cover what was once a fertile land and that many countries, such as Greece, Tripoli, and Palestine, are now only able to support a fraction of their previous populations. We hear from the ancient historians of the intense cold of Greece, then densely wooded, and the perpetual spring of Babylon. The Babylonian tablets of great antiquity refer to the attempts to reclaim the country thrown out of cultivation by the sinking of the spring level and erosion, but these were of temporary benefit. The floods from the mountains increased year by year, the beds of the rivers were scoured out, and irrigation eventually became impossible, for, as with canals so with rivers, the flow is regulated by control at the headwaters. All these countries are now more or less desert and it will be interesting to see how far the effect of forest clearances has been felt in the United Provinces. It is proposed, however, to deal with the country washed by the Jumna river.

THE JUMNA VALLEY.

The Jumna takes its rise in latitude 31° 2′, longitude 70° 27′ about 5 miles north of Jumnotri and 8 miles west of Bundarpunch peak in the Himalayas. Its length from source to confluence with the Ganges is 860 miles. It has 17 tributaries of which 5 rise in the Himalayas, 3 in the Siwaliks, 3 in the Vindhya Hills, 1 in the Satpura Hills, and 5 in the plains of the Doab. If the reader will pick up a map showing the distribution of forests in relation to these rivers, he will see how insufficient is the regulating belt of forest to control

the headwaters and in many cases this is absent altogether. In addition to this insufficiency many of the forests are open to grazing and browsing of cattle, resulting in the protective covering of grass being cleared off the ground, and the young forest seedlings are eaten down or die through having no depth of soil : in this way the forests eventually become exhausted and disappear. Anybody who has visited the Dehra Dun and Saharanpur districts cannot fail to be impressed with the enormous damage done by sudden floods from the Himalayas and Siwaliks, and it is not surprising to find that the area under cultivation in many villages of the Saharanpur Terai has decreased during the last 50 years. The submontane rivers have been continually changing their courses ever since the hills came into existence causing the land to be covered with a deep boulder deposit. If grazing were entirely excluded the old beds would very quickly become covered over with a dense *shisham* (*Dalbergia Sissoo*) and *khair* (*Acacia Catechu*) forest which forms very efficient natural training and obstruction works against the force of the floods. Unfortunately a large portion of these forests are open to grazing and the young seedlings are browsed down every year, the beds have widened and the force of the floods has increased. The vegetation on the neighbouring hills is of a very poor description after centuries of abuse and, owing to much of the soil having been carried off, the water flows away with great rapidity, thereby increasing the volume of the torrents and leaving the beds dry a few hours after a storm. Irrigation works have been destroyed by these sudden floods and they are a source of anxiety to the engineer. A similar state of affairs can be found on almost every hill tributary of the Jumna.

The accumulated effect of this flooding and scouring has resulted in the bed of the Jumna at Etawah being lowered 60 feet in the last 500 years and a corresponding sinking of the spring level. The cold weather level of the river in the Etawah and Jalaun districts is often 120—200 feet below the general level of the surrounding country. The sinking of the bed of the river is draining the country, and the well water levels are sometimes as low as 200 feet. The banks of the Jumna in the Agra, Etawah, and Jalaun districts are

now so completely drained that they have become almost destitute of vegetation except a desert flora, and even this is disappearing. This dry belt is increasing at the rate of 250 acres each year in the Etawah district alone. The absence of protective vegetation on the banks and the flow of water from the high plateau to the river has caused a complicated network of ravines to be formed. These ravines often start suddenly at the edge of cultivation with a drop of some 80 feet or they may be less severe, and they take up a meandering course, joining up with other systems, eventually falling into the river. The actual area of these ravines in the Etawah district alone is 120,000 acres and the area of similar land in the provinces is some millions of acres. The land is at present almost valueless to the owners as it yields grazing of the very poorest description. Cultivation beyond this desert belt is precarious even in years of almost normal rainfall, and drinking water often becomes so rare as to necessitate the migration of whole villages, and throughout the whole expanse of the ravines there is no water to be found except in the main rivers. A study of the soil will show that it is very fertile, but it is too cut up and arid for cultivation. The monsoon rains only sink to a depth of seven inches, and below this the soil is quite dry till the spring level is struck. It would appear that the present tree growth is of very great age which has continued to reproduce itself by coppice shoots and the root system has kept pace with the sinking spring level : natural reproduction invariably dies down as soon as the rains cease.

The drying up of the country is a most serious matter which may be temporarily relieved by the expenditure of lakhs of rupees on irrigation, but, if the erosion of the country continues at the present rate, irrigation projects will be hampered and eventually become impossible. The Etawah District was once covered with *sal* (*Shorea robusta*) forests and many villages are named after the tree— Sakhi Sakrauli, Sakhua, Sakhopur—and it is recorded that the Emperor Babar hunted in these forests. The *sal* tree requires a moist climate, but the conditions have so changed that there is not a single tree between the Himalayan Terai and the Satpuras. The drop in the Jumna level is established by the prevalence of old

sugar mills in the Etawah trans-Jumna area where the water level is now far too low to admit of irrigation, and also in the fort at Shergadh near Auraya the curb of the large well in use in 1550 is now 60 feet above mean flood level.

RAVINE RECLAMATION.

The question of utilizing these waste lands in the Agra, Etawah, and adjoining districts for fuel and fodder reserves has often been the subject of investigation by Government. The earliest report on record is that of Dr. D. Brandis, then Inspector-General of Forests to the Government of India. The measures recommended in this report for the encouragement of forest growth were—(1) fire protection, (2) restriction of grazing, (3) protection from all wood cutting, (4) filling up of blanks by planting and sowing. Enquiries were shortly afterwards made as to the areas of waste lands which could be utilized as fuel and fodder reserves, but action was deferred on the ground of the enormous expense involved. However, in 1882 Mr. J. E. Fisher, Collector of Etawah, called together the zemindars who owned the tract of ravine land to the west of the town of Etawah, and these owners agreed to hand over their land for the creation of a fuel and fodder reserve for the protection of the ground from erosion and further deterioration. The owners of the land were to provide the necessary funds, and in return the profits were to be divided *pro rata* according to the money furnished and the land held in each case. The management of the reserve was entrusted to the Collector, who placed the area under working in the same year. Grazing was prohibited, the soil broken with the country plough, and the seed of *babul* (*Acacia arabica*), *shisham*, and *neem* (*Melia indica*) sown. In order to dam up the rain water and locally raise the spring level, *bandhs* (embankments) were thrown across the ravines in suitable places. It appears from the scanty information available that the small expenditure incurred was more than recouped by the sale of grass and subsequently by grazing dues and light fellings. The scheme worked well for

a time, and there was eventually a fairly good crop of *babul* sufficiently dense and valuable to encourage a firm to take over the forest for the tan bark on a lease of 50 years on payment of approximately Rs. 2 and an annual rental of R. 1 per acre.

Again in 1901 a small area of ravine land was acquired close to the town of Kalpi, Jalaun district, for the supply of *babul* bark to the Cawnpore tanneries.

Experiments in Etawah.

In 1912 the Local Government having defined its policy with regard to the re-afforestation of denuded areas and the establishment of fuel and fodder reserves, a preliminary survey was made of existing waste lands, and a report was submitted recommending, in the first instance, the reclamation and utilization of the ravines along the Jumna and Chambal rivers in the Etawah district. The owners of the land were approached and a scheme, somewhat on the lines already referred to in connection with the Fisher forest, was agreed upon, but in this case Government undertook to pay the cost of afforestation and to recoup the expenditure out of the revenue, eventually handing back the lands when the debt had been cleared. In this way the area taken over for reclamation up to date is 22,000 acres and additional land has been promised. The first two years of operations have been of an experimental nature and they have beyond doubt proved the possibility of reclaiming and utilizing these lands as fuel and fodder reserves. There is also every prospect of raising small timber. That plantations successfully raised would be of great economic importance is certain, the high price and scarcity of building timber is well known, there is an ever-increasing demand for firewood, and the demand for tan stuffs is almost unlimited. Local industries are sure to spring up and will add to the prosperity of the district.

The soil of the ravines is of an alluvial type, differing only in texture from place to place. This class of soil requires constant cultivation, as, owing to its fineness, natural aeration is obstructed, and, on drying, the soil solidifies to the consistency of rock. The

re-establishment of sufficiently favourable conditions for vegetation is the preliminary object; this can only be done by improving the soil aeration and moisture content and can be at once effected by breaking up the compact surface soil and so aiding the gaseous exchange between the soil and air. This operation also assists the penetration of moisture into the substratum. It is also necessary to preserve the continuous gaseous interchange between the soil and atmosphere and to prevent further consolidation. Irrigation is, of course, impossible owing to the ruggedness of the ground. Soil cultivation, extended over several years, is impracticable in a forest estate owing to the comparatively low final returns, and could only be carried out for two years at the most, even if only valuable tree species were raised. It is considered, however, that if once a forest can be established the roots will penetrate in all directions into the subsoil and will break it up sufficiently to allow of aeration and moisture soakage. The shade of the trees will doubtless prevent excessive consolidation, the litter and grass growth will retard the present rain wastage, and the water which escapes can be caught in small ponds held up by *bandhs* thrown across the ravines, or by blind ditches and embankments on the higher ground. It is also very important that cattle should be kept out of the plantations until they are established as, besides browsing, the tread of cattle hardens the crust of the soil and destroys all the effect of cultivation. For breaking up the soil no better instrument can be found than the Sabul plough, but owing to the roughness of the ground a great deal of work has to be done by hand. The Changa Manga plantations, near Lahore, which form, perhaps, one of the finest afforestation achievements in the world, exist entirely by irrigation, whereas in Etawah where irrigation is not feasible, the plantations depend solely upon intense initial cultivation. It is not possible at present to say which system will produce the greatest net return, but the Etawah plantations are no doubt hardier and less liable to insect and fungoidal attacks.

The first noticeable effect of breaking up the soil and conserving the water is the disappearance of the original worthless grasses and their replacement by those of good feeding value. The water wastage

is further checked by the heavy grass growth and the beds of the *nalas* (ravines) become covered with turf. Sowings of various forest trees have been made on the freshly broken up lands, and it is found that many valuable species can be raised, among which may be mentioned teak, *shisham*, *kamhar* (*Gmelina arborea*), and *babul*. The success of these sowings during the last two years has been very satisfactory, and in many places the growth is so dense that it is almost impossible to walk through it; many of the trees sown in 1915 are more than 20 feet in height and are already fit for fuel.

An examination of the conditions after these operations shows that the moisture penetration has very materially improved and that erosion has been effectively arrested: it is, however, essential that a broad protective belt of land at the head of the ravines should be afforested to prevent further encroachment inland. Some portions of the areas, less liable to erosion, will be reclaimed as grazing grounds and will be maintained by periodic cultivation. The improvement of village grazing grounds throughout the province by working them on an interchangeable rotation is a matter which deserves the attention of the country so as to relieve the forests of grazing. Up to March 1917, 1,325 acres of ravines had been reclaimed and afforested at a cost of Rs. 78,368, or approximately Rs. 60 per acre, inclusive of all charges. There is every indication that the cost can be considerably reduced, and that the ravines can be profitably utilized for fuel and fodder reserves. The plantations require very great attention and care during the first few years as they are subject to the attacks of all kinds of enemies.

The reclamation of ravines is a work suitable for famine labour as the work can be closed down at any time without leaving it incomplete and the extension of fodder reserves will be a valuable asset in time of scarcity.

The reclamation of ravines is, in the writer's opinion, however, somewhat similar to curing the pain without eradicating the main cause of the malady. The cause can be traced to the forest denudation at the distant headwaters of the rivers, and it is important that it should be also dealt with there. Much has been done during the past

few years to preserve and extend the existing forests in the Himalayas, but much still remains to be done, or we may expect the fate of Babylon. Champollion in referring to the deserts of Northern Africa wrote: "Does any crime against Nature draw down a more dreadful curse than that of stripping Mother Earth of her sylvan covering?"

SELECTING SUGARCANE BEFORE PLANTING: SOME DEMONSTRATIVE EXPERIMENTS.*

BY

ARTHUR H. ROSENFELD.

In these days of liberal education, agricultural extension, and Nature study—in these times when Mendelism is discussed by the high school youth and Darwinism is a fireside topic in the home of the family of average education—the principle of selection of any plant or animal for the maintenance or improvement of its characters would seem so axiomatic as to render *experiments* along this line unnecessary. Nevertheless, it is often the case that the most common facts are those which we ignore in our daily agricultural routine, and it frequently happens that experiments along the most common lines of investigation, conducted on sound scientific and practical principles, result in calling the attention of the agriculturists to facts not unknown but *forgotten*. In this article, recognizing as accepted by every intelligent agriculturist the principles and value of selection in general, we shall limit ourselves to describing and drawing some conclusions from two series of experiments in the Tucuman Experiment Station (Argentina), made while the author was director of that institution, in selecting cane before planting.

The selection was made principally with the object of planting cane as free as possible from infestation with the common moth stalk-borer, *Diatræa saccharalis* Fab. form *obliterellus* Zell.,[1] but the lessons gleaned from the results may be taken as indicative of the value of selection of cane in general. Selecting canes free of borer attack and the diseases introduced through the perforations means

* Reproduced from *The International Sugar Journal*, February 1918.

[1] *The International Sugar Journal*, 1916, pp. 18–19.

simply the selection of sound, healthy canes, and this is the basis of all seed selection. It must be stated at the outset, however, that, on account of the extreme severity of borer infestation when we began the experiments, the selection of the borer-free canes did not represent as careful a selection of other characteristics than freedom from the borer as we would have wished ; in fact, it was evident at a glance that the *selected* cane was inferior in general appearance, as regards size, development, etc., to the ordinary cane for the test lot. This was undoubtedly due to the fact that the larger, thicker canes offer individually a larger surface to the attacks of the borer, with the result that in cases of very heavy infestation with the borer, a larger proportion of thin canes will be found free of the borer than of the thicker, better developed specimens. Hence, although these experiments were made on a basis of selection against borers only, common sense tells us that the improvement in results should vary in direct proportion to the *thoroughness* of the selection.

It is probably unnecessary, treating of careful experimental work, to call the attention of our readers to the fact that, outside of the actual selection of canes as free as possible from borer attack and the cryptogamic diseases which gain entrance to the cane through these perforations, there was absolutely no difference in any phase of the cultivation of the selected and non-selected plats of cane, the latter plat having been planted with the type of cane usually planted in this province and elsewhere where selection is not resorted to—cane of good appearance in general, but without any attention having been given as to whether it was infested with borers or whether a good proportion of the eyes had been destroyed by this insect or other causes. In every case both lots received equal treatment throughout from the time of planting to that of harvest, both plats were exposed to identical climatic and other conditions, and every operation of cultivation, irrigation, fertilization, etc., was made in the two plats on the same day.

The first experiment was begun by the author in August 1910, shortly after his arrival in Tucuman, and was one of the first experiments undertaken in the Tucuman Sugar Experiment Station. Careful counts were made at frequent intervals of the number of

sprouts above ground in the two sublots, the difference in appearance between the plats planted with selected and unselected cane being most notable from the beginning of the germination, that planted with selected cane, for example, having the rows plainly delineated with healthy sprouts on 1st October, 1910, whereas only an occasional plant was found at that time in the unselected plat. Table I gives the results of these germination counts at various dates, in number of sprouts above ground per row of 100 metres, the usual basis of calculation in Tucuman.

TABLE I.

Germination counts in the first experiment.

Plat	Oct. 17th	Dec. 1st	Dec. 12th 16th	Crop
Selected ..	153	606	1,203	1,111
Unselected ..	44	464	874	942

A study of this little table reveals some very interesting facts. It will be observed that, in every count, the selected cane showed much better germination than the unselected—so much so, in fact, that all canes which existed at the time of lay-by in December could not mature, the number of matured stalks, however, still being far superior at crop time in the selected plat than in the unselected, although there was an increase of stalks in the latter plat between lay-by and harvest. It is interesting to note, also, that the average weight of stalk from the selected plat was just 40 grm. more than that of the stalks harvested from the unselected plat.

No clearer demonstration of the value of selecting cane before planting could be desired than the difference here shown between the number of stalks germinated and produced in the two plats. This difference in germinating strength is made all the more clear when we study Table II, which gives us the plant and stubble cane yields of these two plats—of the crops of 1911 and 1912 respectively—showing how this difference in germinative potentiality is translated into difference of cultural yield, bearing in mind always that the same or less money will be spent on producing inferior cane per acre as on producing good cane, and, hence, that the cost of cultivation *per ton* of superior cane is always vastly inferior.

This table would appear to demonstrate, therefore, that in planting unselected cane we are only putting into the ground a vast amount of cane which cannot possibly germinate with full efficiency and which would have been much better made use of by sending it to the mill, replacing it with selected canes whose potential germinative power would have insured a more profitable investment in the plantation.

Now let us examine for a moment the cultural yields of the distinct plats in the crops of 1911 and 1912.

TABLE II.

Yields in the first series of experiments.

Plat	PLANT Per row 100 metres	Kgs. Per hectare	STUBBLE Per row	Kgs. Per hectare
Selected ...	954	62,964	582·3	38,432
Unselected ...	776	51,216	481·3	31,766

From this table we learn that the selected cane, both as plant and stubble, has given far superior yields to those of the unselected—over 20 per cent. in each case. This increase in production, with the same or smaller cost of cultivation per acre, certainly many times repays the small cost of selection, the only item of expense, above all when we consider that, in Tucuman at least, where cane is left as stubble for many years, this selection has to be made but one year in order to reap the benefits during several.

An interesting part of this experiment was the determination, by the careful examination of several hundred individual canes from each plat, of the percentage of canes containing living cane borers at harvest. The results of the counts showed that 37 per cent. of the selected cane plat contained live specimens of *Diatræa*, whereas 60 per cent. of the canes harvested from the unselected lot harboured this enemy of our cane fields. That is to say, that even in small lots, a careful selection of the cane, as free as possible from borers at the time of planting, gives direct results in the consequent infestation with this insect. As we know that the moth of this insect is not a strong flyer, it is quite logical that this result should be very pronounced when selecting cane for planting large areas.

In considering the question of borer infestation, it must be borne in mind that the effect of heavy infestation by this insect is very marked on the manufacturing value of the cane harvested, tending always to increase milling difficulties, decrease extraction and sugar content of juice, and invert a part of the crystallizable sugar. Consequently any measure that we can take to reduce the infestation with this insect gives us not only more cane per acre, but cane of far superior manufacturing value, and *cane which will produce us more sugar at cheaper cost.*

The experiments just described were made with ordinary purple cane (Cheribon) of the country, and, in order to continue the demonstration of the benefits of selection to the Tucuman planters, another series of experiments was commenced in the winter of 1912, using this time the striped cane of the country as the basis of comparison. We will only review these experiments lightly, as their results served in every way to justify those from the first series. It may be said in passing that, in order to vary the conditions as much as possible from those of the first experiments, this cane was planted in unirrigable land, the previous series having had irrigation. In both series the cane was planted in rows 5 ft. apart, employing two complete running rows for planting,[1] and in both series, to facilitate examination for borer attack in the selected lot, and to have conditions equal with the cane for the check lot, the cane for planting was hand-stripped. In both series, also, the seed cane was covered in the rows with a small share plough instead of with spades, as is usually practised in Argentina.

As in the previous experiment, three germination counts were made during the spring, with the results shown in Table III.

TABLE III.

Germination counts in the second experiment.

Plat	Oct. 18th	Oct. 26th	Nov. 14th	Crop
Selected	140	356	636	660
Unselected ..	120	292	464	524

Although the difference between the number of sprouts above ground in the two plats is not so striking as in the counts of the first

[1] *The International Sugar Journal*, 1917, pp. 20—23.

series of experiments, they nevertheless plainly show the advantages of selection.

Now, let us see the results of the crop made on August 15th, 1913.

TABLE IV.

Yields in the second series of experiments.

Plat		Kgs. per row of 100 metres	Kgs. cane per hectare
Selected	...	662·8	43,745
Unselected	...	547·7	36,148

Here, again, we find more or less the same increase of yield of the selected over the unselected cane as in the other two crops—just a little over 20 per cent.—all of which gain represents *pure profit* to the planter, as he would have spent the same amount, or more, in cultivating an acre of the unselected cane as of the selected. An idea of what this profit meant in 1913 may be obtained from the fact that in that year cane sold at about one pound and a half sterling per ton, so that the net profit to the planter in that year from selecting his cane for planting would have been in the neighbourhood of *four and a half pounds sterling per acre*, with every probability, furthermore, of obtaining additional profits for several years to come in the stubble cane.

We consider the results of these experiments to be very striking, and trust that they may induce a few readers of the *International Sugar Journal* to undertake a more systematic selection of their seed cane, always bearing in mind that the cane rejected for seed does not represent a loss in any sense as it can always be sent to the mill for grinding.

SCIENTIFIC PROGRESS IN SUGAR CULTIVATION AND MANUFACTURE IN JAVA DURING THE LAST THREE YEARS.*

BY

H. C. PRINSEN GEERLIGS, Ph.D.

As we had occasion to mention in a former article in this Journal [1] on the Java sugar industry, the sugar crop of 1914 proved a bad one, and the 1915 crop, which was then reported as threatening to become worse still, came fully up to the most gloomy expectations. In 1914 the total output of sugar was 1,382,825 long tons; the sugar produced per acre amounted to 8,676 lb., with a yield of 9·28 per cent. on the weight of cane; while in 1915 the figures were: total production, 1,299,272 long tons; production per acre, 7,786 lb.; yield per 100 of cane, 9·15.

A series of very dry years had drained the water sources in the mountains, with the consequence that insufficient irrigation water was available for properly raising the crops. Rice cultivation was backward; consequently the fields were not vacated for cultivation with cane at the most favourable period, and, further, there was also a lack of water for the irrigation of the young cane plants, all of which caused a serious shrinkage in the production. It is evident that the cane, which had suffered from the unfavourable conditions, did not resist the attacks of diseases and animal pests, and thereby yielded less return than it would have been able to do if these misfortunes had not befallen it.

It is not to be wondered, therefore, that many onlookers, who saw the attacks of the diseases and pests, but who did not pay full attention to the primary causes which had stimulated their activity,

* Reprinted from *The International Sugar Journal*, February 1918.

[1] *The International Sugar Journal*, 1915, p. 454.

mistook the effect for the cause and complained of slackness in the eradication of disease and insect pests, and also spoke of a degeneration of the cane, it having, they urged, outlived its use and needing to be replaced by a new and sounder variety.

It, however, soon became patent that, although the complaints were not entirely without foundation (as we shall see later on), the real cause was the bad weather and the great droughts which prevailed during the vegetative periods of the cane for the 1914 and 1915 crops. The cane was not replaced by any other variety, the diseases and insect pests were not more strictly countered than before, and yet the 1916 crop, and still more so that of 1917, were much better; and the latter may even be considered as a record crop, as far as the output of sugar per acre is concerned. The real figures are not known in Holland yet, as the records of the 1916 crop, made up in Java, have got lost during transit to Europe, and duplicates have not arrived, while telegrams from Java to Holland have been held up by the British Government since October 2nd, so that no information by cable could be obtained. Yet from inside information we can mention some figures, which show that the total area has not been increased to any notable extent. The crop of 1914 was raised from 366,000 acres, that of 1915 was the product of 371,954 acres, that of 1916 was of 387,917, while the latest estimate of the area for the 1917 crop amounts to 394,350 acres. The increase in acreage is therefore decidedly insignificant and does not imply anything but a normal extension in small lots; and this fact is in striking contradiction to the opinion expressed in some sugar papers, that the Java sugar industry has extended itself enormously as a consequence of the war. The area under cane has remained pretty much the same, the number of factories has not changed, new machinery has not been installed, not being, by the way, possible because the carriage of heavy machinery to such an out-of-the-way spot as Java was impracticable during the period of the war. In most cases even heavy repairs have been impossible and renewals have not been thought of, so that when Java has seen her sugar production greatly increased, this is only due to the fact that in the previous years the crop had been bad, that of 1916 normal, and that

of 1917 extraordinarily good. The 1916 crop has been put at a figure of 1,591,181 tons or 9,193 lb. per acre, while that of 1917 is estimated at 1,800,000 tons or 10,167 lb. per acre.

This shows how great the influence of the weather has been; it even made up for the want of nitrogenous manures, the exportation of which to Java had been interfered with by the belligerent powers.

In our 1915 article on this subject we had the opportunity of mentioning that the new seedling varieties grown in Java were no longer so healthy as originally, and that many observers ascribed the inferior results of the crops during the years 1912 to 1915 to a so-called degeneration. In fact, the canes raised from tops of cane taken from the old fields when being harvested showed ever-decreasing results; they remained small, dried up quickly, contained a poor juice, and, in short, behaved just like our old Black Cheribon cane in its bad days, so that the old times of the *sereh* disease seemed to have returned.

Our readers are aware, that about the year 1885 the excellent variety, then universally planted in Java, was attacked by a disease and as a consequence almost totally wiped out of existence. It was found that the good qualities of that cane could be maintained if the young fields were not planted from tops taken from the old cane, but were raised from young canes grown specially to that end in remote, mountainous spots where they were immune from disease. This palliative saved the situation for a long while, till the advent of the brilliant new cane varieties raised from seed and propagated by cuttings; but the expenses incurred in the special raising of young canes in distant spots and the transport of the cuttings to the cane districts were so high as to compromise seriously the profits of the sugar estates. When therefore the seedling canes proved a great success and gave a progeny which kept its good qualities after being planted from adult canes cut at their period of ripeness, this method of propagation was followed, just as in every other cane-growing country, and all the money, formerly spent in the nursery fields, was saved.

It appears, however, that in the climate of Java this method is not practicable and leads to inferior results in the long run. The

unfavourable weather of the last few years has emphasized the situation, and the planters have, to a great extent, resorted to their old method of planting nursery fields for tops in favourably situated spots. The much better results of the 1916 and 1917 crops are therefore not exclusively due to the better weather, but also more permanently and more reliably to the greater care bestowed on the planting material.

In years such as 1915 and 1916, when the price of sugar was high and sales went smoothly, the great expense connected with this method of procuring seed was not unduly felt; but it is very likely that prices will not remain indefinitely on a high level and, in fact, in Java they were not high in 1917, with only one-third of the crop exported up to the end of November, and the balance of over a million tons lying idle in the warehouses on 1st December for want of ships to carry the sugar to the destinations where it is so badly needed. It is therefore not surprising that serious measures are contemplated with a view to reducing expenses.

A proposal has been made that carefully selected healthy canes of the good varieties should be planted in a special field in the hills where every cane plant is cared for individually, and where a most vigilant watch is kept over them, so as to procure the soundest and best specimens possible. Some of them are kept there and planted afresh, while others are transplanted to another spot and propagated under good observation. The tops grown there are distributed to the sugar estates, which can multiply them or plant them in their fields just as they like, but they do not plant new fields with the tops of adult canes. If during that period a cane becomes diseased, it ends its career and also its disease in the cane mill, and new fields are planted anew with tops from the new generation reared in the mountain nurseries. In this way it is contemplated to obtain sound and rich canes with a minimum of expense.

At the same time efforts are constantly made to raise new varieties, which will have to replace the old ones in case these should get hopelessly diseased. In former times, the raising of these varieties was done without any thought-out plan, and had more the character of a lottery than of good scientific arrangement.

If a good variety had been obtained, no one could trace back its origin, and, in order to remedy that, the Experiment Station now raises seedling canes on Mendelian principles, and carefully records the progress made in the cross-fertilization of canes from different varieties. If once, by this methodical research, a new variety is evolved, which combines excellent qualities, this cane may at any moment be obtained again by following the lines laid out in the plan and noted down in the records of the Experiment Station. Up to this moment the scientists of the station have not yet raised a variety which can replace the excellent ones now in cultivation, but they are confident of reaching their goal and presenting the industry not only with a good sound cane, but also with the recipe to get it again, if through misfortune the one now obtained should lose its qualities.

No new diseases or serious attacks of insects have been recorded, save, of course, the already-mentioned consequences of the drought and unfavourable weather which weaken the cane and make it suffer more than in ordinary times. Good work has been done by the entomological staff of the Experiment Station in observing and studying the parasites of the boring caterpillars infesting the cane. The habits of a great number of wasps, flies, and other parasites, attacking both the eggs and the caterpillars, were studied, and the best way of disseminating these over the cane fields was tried, with good results so far as could be ascertained in so difficult a matter.

The boring caterpillars constitute the worst enemies of the cane among the insects in Java, and every expedient to reduce their number is cordially welcomed, but the habitat of the grubs in the interior of the stems protects them so well against attacks by parasites that the contest with these borers is a very difficult one, even with the aid of our little helpmates, the ichneumon flies.

The war has put a temporary stop to the trials made in mechanical soil tillage. Extensive experiments were being made with digging machines, motor-ploughs, Archimedian screws propelled on railway trucks, and other devices, but in these times the machinery shops are making other implements than agricultural ones, and

even if they made them they would not be shipped to Java; and consequently nothing new can be said on this topic.

The geological survey of the districts devoted to cane cultivation, prepared by the surveyors of the Experiment Station, has been completed, so that the different strata of land can now be charted, thus enabling the planters to see at a glance what particular kind of soil they have in their different fields, and so ascertain how best to till and fertilize these, and with what cane varieties to plant in order to gain the best results. This feature is of much value for the future, as thereby the experience of contemporary planters is no longer utilized solely by the workers of the present generation, but may serve for the advantage of later ones, who can find in the archives of the estate the results of work based on the scientific survey.

The problem of fertilizing has undergone a change within the last few years through a shortage of sulphate of ammonia which constituted the most universal fertilizer for sugarcane in Java. In some places a little superphosphate was also used, but in general sulphate of ammonia reigned supreme. The German product could not be imported, while the British and Japanese supplies were not allowed to be shipped to Java, and the planters were compelled to look out for substitutes. Extensive experiments had showed in former years that every nitrogenous fertilizer could be applied to cane; that ammonium sulphate was by far the cheapest, the most handy, the best to store and distribute, but that Chile nitrate and the organic fertilizers, such as castor oil and groundnut cakes, bat's dung, etc., were also good in use, but had either disagreeable properties or attracted moisture from the atmosphere, or were not so economical. In these days when we have no choice, all these secondary considerations must be disregarded, and hence the substitutes which in ordinary years were neglected are now generally used with good results.

The manufacture of sugar has not found an opportunity for recording new features in the years under consideration, which is not to be wondered at, considering the difficulty of obtaining new machinery and the very small chance of getting renewals or

improvements executed. The experiments made in Java by the Experiment Station people with the Messchaert grooved rollers have not been successful, and contrast strongly with the results obtained in Hawaii.

It appears that the cane fibre in Java is much harder than that in Hawaii, and this circumstance is of great significance in the extraction, since the good results which the new appliance has had in the Hawaiian Islands have not been experienced at all in Java. A commission sent out to the Hawaiian Islands with an aim to investigating the results obtained with the Searby shredder came to the conclusion that the Hawaiian bagasse is much more easily reduced to a soft pulp, thus readily giving up its juice, while in Java the fibre is much harder, and the parenchyma on the contrary rather soft, so that it forms a sticky mass with the hard fibre. They believe that if the cane in Java is shredded by a Searby shredder, which breaks up even the hardest rind, the condition of the bagasse may become the same as in Hawaii, and that, after passing it through the shredder, the Messchaert grooving of the rollers may have a very beneficent influence on the juice extraction.

It has been observed that the mill control, as required by the Experiment Station, was much too intricate and too troublesome for practical use, and that considerable simplification might be considered. The result of recent deliberations was, however, that the figures required were really necessary to obtain a good insight into the milling work, and that it was obligatory to collect these data in order to serve as a basis for improvement as soon as a falling-off in the efficiency of the mills was noticed.

An example of the excellent results of careful mill control is given by the fact that large losses of sugar, which till recently escaped detection, are now brought to light by the close control. It was originally the custom to ascertain the amount of sugar in juice and in bagasse, and to consider the amount of sugar in cane to be the sum of these two, making no allowance for unaccountable losses during milling. The new control records the amount and sugar content of the different mill juices separately, and that of the total of the mixed juice; and it found in many instances that the amount

of sugar in the mixed juice was smaller than that of the sum of the component parts. This strange phenomenon could not be ascribed to a personal error, as the weighings and determinations were all made on the same scales, with the same instruments, and by the same individuals, and, notwithstanding, always tended in the same direction. It was found that in the tanks, gutters, collectors, etc., of the juices, especially those of the maceration with last mill juice, such huge amounts of bacteria, yeasts, and fungi could accumulate, that large quantities of the sugar, amounting to as much as 6 per cent. of the total quantity, were lost by inversion. The new control can detect these losses, which may be rather easily overcome by continually cleaning the conducts through which the juices pass or even by using double sets of tanks, suction pipes, collectors, stone-catchers, etc., of which one set is cleaned and disinfected, while the other one is working. This rather simple device has already reduced these unaccountable losses in many factories to an insignificant fraction of their former sum, thereby proving that they had really existed and were not a consequence of errors.

The manufacture of plantation white sugar is still of the greatest interest for the Java sugar industry, since not less than one-half of the crop is sold in this assortment. The experiments made with the new patent decolorizing carbon, Norit, appear not to have had the desired result, as the factory in which extensive experiments have been made still continues to sell refining crystals and no white sugar. The obstacles connected with the revivification of the charcoal appear to offer great difficulty and the patentees advise us now to use the powder for the decolorizing of dissolved raw sugar instead of for the juice. The process becomes therefore a kind of refining process instead of sugar manufacture direct from the juice.

Discussions as to which process—carbonation or sulphitation—is the most economical and the most reliable, are not yet finished; both have their advocates, and that proves that the difference cannot be very great, for if it was, the question would long ago have been settled.

A new crisis has arisen for the Java sugar industry on account of the difficulties over the transport of sugar. As we mentioned above, one million tons of sugar of the 1916-17 crop are still waiting transport at a time when usually all sugar is shipped. It is clear that the usual storage accommodation is insufficient to stock that quantity, all the more so as other Java products such as coffee, tea, tobacco, spices, etc., are also held up for transport and meanwhile demand godown space. The factories have built stores to hold the sugar in, and though these are necessarily emergency buildings, they had to be constructed in such a way that, at any rate, the moisture of the air, during the rainy monsoon from October to April, did not affect the sugar and cause it to get moist. The problems connected with the proper storage of these large quantities of sugar have been energetically studied, and we are sure that, guided by the experience and the investigations conducted for years in the province of storing sugar during the rainy season, the manufacturers will have taken every precaution to maintain the good quality of their sugar till the time comes when transport will be normal once more.

MOTOR TRACTORS: UTILITY FOR TILLAGE PURPOSES.

THE Engineering Correspondent of *The Times of India*, in a letter, dated London, April 9th, 1918, writes:—

A recent paper read before the Institution of Mechanical Engineers by Mr. Arthur Amos, of the School of Agriculture, Cambridge University, entitled "The Utility of Motor Tractors for Tillage Purposes," is of considerable interest at the present time when the application of mechanism to agriculture is assuming ever-increasing importance, even where labour is relatively cheap.

The author states that the chief value of the motor tractor to the farmer is that it enables him to get his ploughing done quickly when the texture of the land is best fitted for the work, instead of being compelled to continue ploughing with horses for long periods when soil and other conditions are not really fit. This gives the farmer two great advantages: first, the subsequent cultivations necessary to produce a seed-bed are reduced by perhaps 50 per cent.; and, secondly, if a field is ploughed quickly after the previous crop is removed, weeds are prevented from overrunning the land and are consequently more easily kept in subjection.

At this stage it may be well to state the three most important factors which determine the texture or friability of any soil (there are others of lesser importance). These are: first, the size of the particles composing the soil; if the soil consists mostly of large and coarse particles, then the soil is generally friable and easy to cultivate, as for example, sandy and gravelly soils; but if the particles are small, then the texture becomes more tenacious and sticky, and friability is bad; such soils are generally called clays. Between these two extremes all intermediate types of soil exist. Secondly, texture depends upon the degree of wetness of the soil; most soils when wet (especially the clays) are characterized by a tenacious,

sticky texture, require greater power for cultivation, and become pasty if cultivated, so that subsequently they are difficult to convert into good seed-beds, because such a pasty condition prevents the clods from breaking. As the soil passes from a wet to a more dry yet "moist" condition, this sticky character disappears and the texture becomes more and more friable; in this condition the land is easy to plough, and the resultant ploughing is more easily converted into a good seed-bed. If, however, drying is continued and the soil becomes quite dry, it often sets so hard (especially on clay soils) that it becomes impossible to plough, and only very powerful cultivators, such as those drawn by steam engines, are able to break the land. This dry condition of hard texture of the soil, however, presents one very marked contrast with the bad texture due to excessive wet, namely, that when such dry, hard soil is broken up and subsequently becomes moist with rain, it crumbles into an ideal seed-bed like a lump of quicklime. At present there is no motor-drawn implement which is able to deal with this hard condition of clay land, but it is not impossible that some new implement may be devised to act as a cultivator for use with high-speed engines under such conditions. Thirdly, the texture depends upon the previous cultivation of the land, whether it has been recently cultivated, in which case the surface of soil cultivated is loose, or whether it has become consolidated by long weathering and the trampling of carts, horses or sheep; in the former case the furrow is more easily turned, but the loose surface presents greater difficulties to the effective grip of the tractor wheels on the land, and movement may be impossible; in the latter case the work of the tractor is increased, but, as in the case of a clover stubble, the surface is so firm and solid that the wheels obtain a good grip.

From these considerations, it is obvious that motor tractors have to plough under a great variety of soil conditions, so that it is not to be expected that any one tractor will be the best under all circumstances. With this introduction, it is possible to examine some of the points of agricultural importance in the motor tractor.

POWER AND WEIGHT.

It would seem hardly necessary to emphasize the importance of the tractor being possessed of ample power, but every one may not appreciate how greatly the power required for ploughing different conditions of soil varies. Perhaps the case is best illustrated by reference to horse-ploughing; on some light land three horses will plough with a two-furrow plough two acres in a day, whereas on clay land three horses may only be able to plough half an acre a day. It follows that the ploughing of one soil may require four times the power required by the other, and a tractor that does good work on the one will fail completely on the other.

The logical conclusion from this would seem to be that one type of tractor should be designed for the light land and another for the heavy land, but whilst this may be carried into practice to some extent, it cannot completely solve the difficulty, for on very many farms some of the fields are composed of heavy and some of light land, and moreover in the same field the texture of the soil may suddenly change as one passes from one soil type to the next. These difficulties may be overcome, partly by using a plough with fewer breasts for ploughing heavy land, partly by changing speed when the soil varies, but much the most sensible solution of the difficulty is by fitting the tractors with engines capable of developing ample power for the work for which they are designed. The tractors in use in England at the present time vary greatly in weight, from about 20 cwt. up to 5 tons. From two points of view weight is advantageous: thus weight generally signifies greater strength in construction and less wear and tear; again, a heavy tractor can often obtain a better foothold than a light one upon the land over which it travels. On the other hand, a heavy tractor when used for ploughing suffers in comparison with light tractors in three distinct respects. First, a heavy tractor must consume a considerable portion of its power in merely transporting itself across the field, and this consumption of power increases very greatly when the surface is soft and the "going" is bad; secondly, the dead-weight of the tractor is a very serious handicap upon hilly land, whether,

as is usual, the ploughing is done directly up and down hill, or whether it is done across the slope, in which case the heavy tractor tends to slide down hill; thirdly, and this is the most serious reason agriculturally, a heavy tractor may do untold damage to the texture of the soil over which it travels.

When the soil is dry, no matter whether it be a light or a heavy soil, the pressure of heavy tractor wheels on the soil occasions no damage to the texture of the soil; but when the soil is moist or wet, then the pressure of the wheels tends to squeeze and paste the soil into a consistency resembling brick-earth "pug" (the condition into which brick-earth is worked before being moulded into the shape of bricks). This condition is fatal to the producing of a seed-bed and to the growth of crops, and, if produced on heavy land, may take a rotation of crops (say five years) to rectify. On light soils this condition is much less likely to occur, and if it occurs can be much more quickly rectified.

On light soils generally, and on other soils in a dry state, therefore, a tractor weighing 3 tons to 5 tons may be quite inadmissible, but for ploughing heavy land or loams in moist condition such heavy tractors, unless provided with caterpillar wheels (and these do not obviate the damage completely), are unsuitable. For such ploughing, tractors weighing 30 cwt. or less are more suitable, and even these must be used with discretion; unfortunately, so far as the author is aware, only one such tractor with sufficient power, and this in very small numbers, is available.

The conclusions to be drawn from these remarks are twofold: first, that actual strength required in the construction of different parts of the tractor shall be accurately determined by experiment and not by guesswork; secondly, that when this is known the framework shall be liberally composed of best steel instead of iron, so that weight may be reduced.

Speed.

Perhaps the most important factor upon which the rate of ploughing depends is the speed at which the tractor travels: the greater the speed the greater the area accomplished; consequently,

it is desirable to obtain as high a speed as possible unless this advantage is counterbalanced by some disadvantage. A further reason for maintaining a comparatively high speed is that the friction exerted between the soil, on the one hand, and the various parts of the plough in contact with it, is a function of the areas in contact at any one time and not of the length of furrow ploughed per unit of time ; consequently, a plough hauled at a comparatively high speed experiences no greater friction than one hauled at a low speed. It should be, of course, stated that the plough does other work besides overcoming friction, which is not reduced by greater speed.

In the case of horse-ploughing the best speed is largely decided by the speed at which the horses can develop between 2 miles and 2½ miles (the normal rate of horse-ploughing is about 2 miles) per hour, as a result of this nearly all types of ploughs have been evolved to suit this speed, and it by no means follows that this form of plough is the best for ploughing at a speed of 3 miles or 3½ miles per hour, a speed at which tractors might well work ; certain it is that some ploughs hauled at such speeds by motor tractors accomplish very bad ploughing. Nevertheless, because of the eminent advantages of this higher speed, it is desirable that both tractor-makers and plough-makers should consider these points, and test such problems experimentally.

Wheels and grip.

When the surface of the land is dry and solid, tractor wheels experience little difficulty in obtaining an efficient grip of the surface, but when the surface is loosened by previous tillage or by wet weather, the difficulty of obtaining foothold is very great. A variety of devices have been tried for overcoming this difficulty, most of which may be classified under two headings : first, extending the area of contact between the wheel and the surface of the soil ; and, secondly, attaching grips or studs to the wheel surface so as to obtain greater friction.

The former of these objects may be obtained either by using driving wheels of large diameter or with wide tread, but the best method of improving the grip on this principle is by the so-called

caterpillar wheels. Theoretically this is an ideal method of attaining the end in view, and in practice the method succeeds and gives to the tractor the best grip on a loose or slippery surface; but one practical difficulty arises, namely, that grit and dirt is always present in the bearings and working parts between the drive and the tracks which consequently undergo rapid wear and tear. But because this method does give the best grip, and because it also enables the weight of the tractor to be distributed over a wider area and thus prevents packing of the soil, it is worthy of extended trial and experiment to minimize this adverse feature of wear and tear.

The second means of overcoming slipping by means of grips or studs attached to the outside of the driving wheels needs careful consideration. It should be recognized that such studs or grips press upon the soil in two directions as the wheel revolves, partly by a vertical pressure and partly by a lateral pressure, and in general it may be said that the vertical pressure by consolidating the soil is harmful, whereas the lateral pressure has a stirring tendency which may be beneficial, especially when one driving wheel runs on the subsoil in the open furrow. It follows that blunt studs should be avoided, and that more pointed and perhaps longer studs or grips will occasion less damage to the soil.

In the case of the lighter motor ploughs and tractors, it is worth mentioning that the practice of running one driving wheel in the open furrow (provided it is not so wide as to press on the furrow already turned) is desirable, because in this position the soil during the ploughing season is firmer and generally drier.

TURNING AT HEADLANDS.

One of the most serious drawbacks in the use of the motor tractor with the common type of multiple plough is the necessity for wide headlands; many of the tractors require one of from 6 yards to 10 yards according to the type of tractor, because they are unable to turn short. A further consequence of this is that the motor tractor has to travel a long distance along the headland, on the average 30 yards to 40 yards at each end, and cases are within the knowledge of the author in which in actual use the tractor has

been running 80 yards and 100 yards along the headland at each end. Now the average length of plough furrow will be about 200 yards, and assuming the run along the headland averages 30 yards, the time lost at the headland will amount to one-seventh of the running time of the tractor. This is a very serious waste of time.

The difficulty does not arise in the case of steam-ploughing, because for this purpose a balanced plough is used which simply requires to be toppled over at each end, and it seems to the author that no insurmountable difficulty would be experienced in designing such a three or four-furrow balanced plough for use with motor power. Such a motor plough would need to have the motor placed in the centre of the implement; it would need reverse gears similar and equal to the forward gears, and would need two sets of controls: the ploughs would be balanced before and behind.

The advantages of such a machine for purposes of motor-ploughing are very great, some of the more important are enumerated below :—

1. Time lost in turning would be greatly reduced.
2. The headlands could be reduced to very narrow limits.
3. The headlands would not be crushed by frequent passage of the motor upon them.
4. The plough would start at one side of the field and work back and forward until the opposite side was reached. All the furrows would be turned in one direction; there would be no ridges, no open furrows, and no awkward narrow widths left for the horses to finish.

NOTE ON THE BALING OF SHAFTAL AND LUCERNE HAY FOR ARMY TRANSPORT.*

BY

ALBERT HOWARD, C.I.E., M.A.,

Imperial Economic Botanist.

THE difficulty in baling *shaftal* (*Trifolium resupinatum*) and lucerne hay, under the dry conditions of Quetta, is to obtain a close bale without, at the same time, damaging the product. Both these fodders dry out so quickly and become so brittle that it is almost impossible to bale them without considerable loss of leaf—the most nutritious portion of the fodder.

These difficulties have now been overcome. If *shaftal* or lucerne hay is allowed to dry outright in small stacks, the brittle fodder can be got back into condition by watering the heap on the outside by means of an ordinary watering can and by covering it up for 24 hours with a tarpaulin or a small tent. The moisture then penetrates the heap and brings the fodder into condition for handling and baling. The outside layers are often a little too damp, but if these are allowed to dry in the sun, for an hour or so, the extra moisture rapidly evaporates. The amount of water required is about 10 gallons for every 150 cubic feet of stacked fodder. To enable the moisture to spread evenly, heaps $14' + 3{\cdot}5' \times 3'$ are quite suitable. Some judgment is required in baling the moistened fodder, but a little practice will avoid any danger of pressing too damp. The best stage is when the fodder is just beginning to feel brittle.

At the suggestion of Brigadier-General Cook, R. G. A., and with the assistance of Major Hislop, experiments have been made at

* Reprinted from the *Journal of Dairying and Dairy Farming in India*, vol. V, pt. 1

Quetta to determine whether or not these leguminous fodders could be baled close enough to meet Army transport requirements. These experiments were duly carried out on August 1st last, by means of the Boomer press at the Supply Reserve Depôt, Quetta, with lucerne brought into condition by damping as indicated in this note.

Two kinds of bales were made with the Boomer press, (1) with lucerne only and (2) with chaffed lucerne and *bhusa* in equal parts by weight, mixed ready for feeding. The lucerne by itself was found to be the more easily compressed. The size of a maund bale of lucerne was 30″ × 16″ × 13″ (equivalent to 97 c. ft. to the ton). The size of the mixed lucerne and *bhusa* bale was 31″ × 17″ × 13″ (equivalent to 105 c. ft. to the ton). The press had not been used for some time and was a little out of adjustment or it would have been easy to compress to 90 cubic feet to the ton—the Army standard for pressed *bhusa*. There is no doubt therefore that these leguminous fodders can be compressed to the required degree. The military advantage of the mixed bale is obvious as the fodder is ready for feeding, and the trouble on active service of dealing with two sorts of bales is obviated.

As regards keeping qualities, there is every reason to believe that no danger need be apprehended from this source. Two bales were opened on August 24th, twenty-three days after they were made, and the fodder in both the lucerne and mixed bales was in perfect condition, with no trace of sourness or mouldiness. A number of others were kept till the following April and were found to have suffered no damage.

Notes.

THE EFFECT ON GERMINATION OF COTTON SEED OF PASSING THE *KAPAS* THROUGH THE "OPENER."

It is the general custom in the Punjab to pass *kapas* (seed cotton) through an "opener" before ginning. This practice is also common in many other parts of India, notably the United Provinces, Central Provinces, and Sind. In the latter the *kapas* is passed through two openers. The object of passing through the opener is to get rid of as much leaf and dust as possible and thus secure a better "class" or "grade" of cotton being turned out on ginning. It is commonly believed that the germination of American cotton is adversely affected by this treatment, especially if the funicle is broken. With a view to clear up this matter, the writer carried out some tests at Lyallpur under Mr. Roberts' guidance. The results are given below (Tables I, II, and III).

TABLE I.

Showing the germination percentage of cotton seed with pointed tips (funicle) intact and the tips broken.

MAY 1915.

Kind of sample	Funicle broken	Funicle intact
	Per cent.	Per cent.
Deshi cotton seed	74	65
American cotton seed	74	70

TABLE II.

Showing the relative germinating capacity of cotton seed passed through the "opener" and that not so passed.

APRIL 1917.

No.	Kind of cotton	Passed or not passed through the "opener"	Immature seed	Foreign seed	Broken seed	Good seed	Total	Percentage of good seed	Germination percentage of good seed	Germination percentage of seed
1	Deshi cotton seed Gojra	Not passed	63	31	22	200	316	63·3	50	31·650
2	Deshi cotton seed Gojra ..	Passed	46	75	22	186	329	56·5	40	22·600
3	4-F. American cotton seed, Gojra	Not passed	100	11	22	474	607	78·0	74	57·720
4	4-F. American cotton seed, Gojra	Passed	10	20	17	254	301	84·3	48	40·464
5	4-F. American cotton seed, Jaranwala	Not passed	26	11	18	454	509	89·2	60	53·520
6	4-F. American cotton seed, Jaranwala	Passed	12	66	26	210	314	66·8	57	36 930

TABLE III.

Showing the relative germinating capacity of cotton seed passed through the "opener" and that not so passed.

APRIL 1918.

No.	Kind of cotton	Passed or not passed through the "opener"	Immature seed	Foreign seed	Broken seed	Good seed	Total	Percentage of good seed	Germination percentage of good seed	Germination percentage of seed
1	Mixed American cotton seed	Not passed	41	43	5	195	284	68 6	44	31·184
2	Do. do	Passed	31	15	5	159	210	75·7	49	37 093
3	Resalewala cotton seed .	Not passed	57	1	2	259	319	81·2	69	56·018
4	Do. do.	Passed	67	5	9	223	304	73·3	72	52·776
5	Mixed American, Tata factory	Not passed	22	18	2	228	270	84 4	76	65·144
6	Do. do.	Passed	41	15	11	170	237	71·8	59	12·362
7	4-F. American ...	Not passed	71	1	11	294	377	77·9	72	56·088
8	Do.	Passed	28	0	7	197	232	84·9	69	58·581
	Deshi cotton seed ...	Not passed	76	19	18	223	336	66·3	71	47·073
10	Do.	Passed	42	25	10	199	276	72·1	61	43·981
	Average of samples	1, 3, 5, 7 & 9	...	.	...	...	...	75·7	66·4	51 1
	" " "	2, 4, 6, 8 & 10	...	..	...	...	...	75 6	62	46·96

It will be seen that germination is not apparently affected to a serious extent. It is of course important that the setting of the knives in ginning should be altered for American cotton to prevent crushing of seed. These results are being put into practice now by the abandonment this year of the condition in auction sales held by the Department, that *kapas* be not passed through an opener. This will facilitate marketing and enable a better class of cotton to be turned out.

In carrying out these tests, it was found very difficult at times to distinguish between partly undeveloped American seeds and large size *deshi* seeds. It was found, however, that by moistening the seed with saliva, the fuzz could be easily removed with the finger nail from American seed, while from *deshi* it could not be thus removed. The point is of some practical importance in classification as disputes sometimes arose especially in the auction sale class with less than 1 per cent. *deshi* or in the pure American class. In the latter class especially buyers sometimes claim *deshi* as being present in traces when it is in reality only a case of frost-affected or undeveloped American seeds.—[BHAI KHARAK SINGH.]

***

COTTON RESEARCH.

A COPY of a very interesting lecture delivered by Dr. Lawrence Balls before the Royal Society of Arts on April 10th has just come to hand. It reviews very briefly the trend of the author's work on cotton in Egypt and indicates clearly some of the difficulties which he, in common with other scientists working in other fields towards similar objects, has experienced. It omits all the details of his Mendelian work on Egyptian cottons and passes over that aspect rapidly, but shows how he was led to study the health of the cotton plant in Egypt, the effects of environment upon it, how he is searching to interpret into exact terms intelligible to the research worker the qualities in raw cotton required by the spinner so that his lecture has a wider bearing than Egypt. Most of these points are dealt with in greater detail in his books, notably the "Cotton Plant in Egypt" and "The Development and Properties

of Raw Cotton." He touched in his lecture on the administrative difficulties of keeping pure a selected strain of cotton when grown commercially, due to the natural cross-fertilization and quite apart from the added difficulty of the mixing of seed in ginneries, and describes the method he was trying to bring into effect in Egypt just before he left. The most striking of the results of researches into the effects of environment on yield mentioned in the paper was that into the root-system of the cotton plant and the depth to which it penetrated, its function as far as absorption was concerned was mainly confined to the lower end. The falling off in acre-yield in cotton in Egypt is thus largely ascribed to the general rise in the level of the water table resulting from the extended use of irrigation. It is well known that the heads of the Irrigation Department in Egypt are now paying great attention to drainage. By an ingenious use of graphs he was able to establish a correlation between the rate of arrivals of raw cotton at Alexandria and the actual rate of ripening of the cotton in the field and to deduce therefrom that the chief phenomenon noted in regard to arrivals of cotton at Alexandria, *viz.*, that the bulk of the crop now reaches Alexandria sooner than it used to do, is most probably due to the maximum rate of production in the field being maintained for a shorter period due to the cutting-off effect resulting from the rise in the water table.

Another entirely separate line of enquiry, but one also very likely to be of interest to all workers on raw cotton, is connected with the question of determining the length and uniformity of staple of raw cotton. The detailed measurement of hairs is too laborious and slow for practical work; the combing out of the hairs to form a halo round the seed avoids sampling error but leads to a method of judging types different from that adopted by the buyer who examines the staple of the ginned lint. Dr. Balls has constructed a machine for which a provisional patent has been obtained whereby the hairs in a tuft of ginned cotton which have been laid out straight and parallel are then delivered in order on a graduated scale—the short ones first, the intermediate ones next, and the longest last. Successive tufts are fed into the machine automatically. Two minutes provides enough classified cotton to weigh out in any desired fineness

of classification, and at the end of half an hour frequency curves of a reasonable and measurable degree of precision can be plotted showing the variation in length of staple within a sample. Owing to restrictions on manufacture, etc., the machine is not yet on the market. As it happened the writer had some samples with him of ginned lint of Tinnevelly selections Nos. 2 and 3. Dr. Balls has taken some of these to put through his machine, and it is hoped he will send an account of how they behave.—[D. T. CHADWICK.]

***

PROHIBITION OF THE IMPORTATION OF COTTON PLANTS, UNGINNED COTTON AND COTTON SEED INTO FRENCH COLONIES.

HAVING regard to the danger which may result from the introduction into French Colonies of cotton seed infected with parasites or coming from areas where the plantations are ravaged by insects, and considering in particular the extensive damage caused in Egypt and Brazil by the Pink Boll-Worm parasite, the introduction of which into Egypt is believed to be due to importation of seeds from India, and into Brazil to seeds of Egyptian origin, and in view of the opinion of the Epiphytic Advisory Committee, it is resolved* by the French Ministry of Colonies that—

(1) The admission and circulation into French Colonies of entire cotton plants or parts of cotton plants, whether green or dry, are prohibited, also unginned cotton and cotton seed coming from Egypt, British East Africa, German East Africa, Nigeria, Sierra Leone, Asia, Brazil, Mexico, the Hawaii Islands as well as from all countries where the import of the said products is not prohibited. The above prohibition applies to all soil as well as to all sacking, boxes and wrappings which have been used in the transport of the articles enumerated above.

(2) The admission and circulation of cotton plants, whether entire or parts thereof, and whether green or dry,

* An extract from "Journal Officiel" May 7th, 1918.

of unginned cotton or cotton seed from any other source cannot be authorized into any French Colonies whatsoever except on presentation of a certificate of origin issued by a competent authority in the place of origin and certifying that the said entire plants or parts of plants of cotton, whether green or dry, or the said unginned cotton or the said cotton seeds have not been harvested either in Egypt or in British East Africa or in German East Africa or in Nigeria or in Sierra Leone or in Asia or in Brazil or in Mexico or in the Islands of Hawaii or in any other country where the importation of the said products is not prohibited. This certificate is only valid if it bears the endorsement of the Governor General, the Governor or the senior Resident in the French Colonies concerned, of the Governor General or the Resident General for Algeria, Tunis or Morocco, and that of the consular agents of the French Republic for foreign countries.

(3) Every entire cotton plant or part of a cotton plant, whether green or dry, as well as every consignment of unginned cotton or of cotton seed presented for importation and coming from Egypt, British East Africa, German East Africa, Nigeria, Sierra Leone, Asia, Brazil, Mexico or the Islands of Hawaii or from a country where the importation of the said products is not prohibited, shall be immediately seized or destroyed by fire at the expense of the holder. The same procedure is prescribed in the case of those imports for which the importer fails to furnish a certificate of origin recognised as valid as well as for the soil, sacking, boxes and wrappings used in transport.

(4) The admission and circulation of entire plants or parts of plants, whether green or dry, or unginned cotton and cotton seed accompanied by a certificate prescribed in Article 2, are not definitely authorised until


Fig. 1. The Holy Shrine of Kerbala.

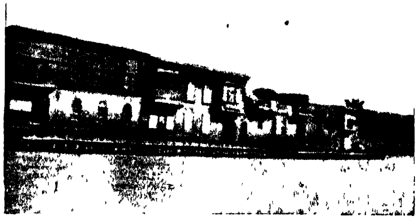


Fig. 2. A typical river village.


Fig. 3. A group of "Fellaheen."


Fig. 4. Iraq buffaloes.


Fig. 5. An old canal bank.


Fig. 6. Iraq sheep.

SNAPSHOTS FROM MESOPOTAMIA.


Fig. 1. Canal and Gardens.


Fig. 2. A Remount Depôt.


Fig. 3. Berseem (Egyptian clover).


Fig. 4. Wheat coming into ear.


Fig. 5. Arab method of planting seedling tomatoes, etc., in shelter.


Fig. 6. Typical land, uncultivated but showir marks of old irrigation canals.

SNAPSHOTS FROM MESOPOTAMIA.

an examination has been carried out by the authority prescribed by the Governor showing that these entire plants or parts of plants and that this unginned cotton and these cotton seeds are apparently healthy and free from pests. Every suspected consignment is immediately seized and destroyed by fire at the cost of the holder.

(5) The terms of the present resolution are applicable to all grains or parts of plants liable to infection by the "Pink Boll-Worm" and particularly to *Hibiscus cannabinus* and *Hibiscus esculentus*.

(6) Infringements of the provisions of this resolution will be punished in conformity with the provisions of Articles 3, 4, 5, and 6 of the decree of the 6th May, 1913, relating to the introduction of plants into the French Colonies.

(7) All provisions inconsistent with the present resolution are hereby repealed.

***

THE **snapshots** given in Plates XXX, XXXI and XXXII were **taken during a mission to Mesopotamia** when the writer along with Mr. Ward, Inspector-General of Irrigation, was sent to advise the General Officer Commanding as regards methods of increasing the food production of the country.

Owing to military considerations it is not possible to go into further details, but the photographs may be of some interest at the present juncture as much interest has been evinced in Mesopotamia.—[G. S. HENDERSON.]

***

WITH a view to conserve the rolling stock and to enable the military traffic to be handled expeditiously certain restrictions were placed last year on the carriage of goods traffic on all Indian railways. Early in the present year all goods bookings to foreign railways were stopped by the B. & N. W. Ry. This created a serious problem regarding the transport by rail of large quantities of Pusa wheat and other seeds intended for sowing in distant parts

of this country. The only course open was to send by passenger train, but it is not economical to send large consignments of seed long distances in this way. Accordingly a large number of indents from Central India, Kathiawar, and Bengal for seed of improved varieties of wheat and other crops could not be met. As one of the ways of relieving the heavy congestion of traffic on Indian railways in these days is to ensure a sufficiency of local produce in each province and thus obviate the necessity of transporting bulky produce, and as one of the easiest methods of increasing the production of wheat and other food grains is the substitution of higher yielding varieties, it was represented to the Central Transport and Foodstuffs Board that it was in the best interests of the railways themselves as well as of the country that facilities should be given to the Agricultural Department generally in the transport of seed of all improved varieties of food grains intended for sowing. The Board have, accordingly, instructed the Directors of Civil Supplies in the various provinces to issue **priority certificates in class 2 (b) for all consignments of improved varieties of seed for sowing purposes booked by or under the orders of the Agricultural Department in future.**—[EDITOR.]

***

THE Advisory Council of Science and Industry of the Commonwealth of Australia has issued a pamphlet (Bulletin No. 5), dealing with **some problems of wheat storage**. The bulletin is divided into two parts dealing respectively with damaged grain and insect pests. The former consists of the report of a committee appointed to investigate the utility of quicklime for the preservation of wheat, in accordance with a scheme outlined by Mr. A. O. Barrett. After careful investigation the committee recommends that the process shall be given a trial. Its experiments and observations indicate that ordinary wheat is improved by the treatment, the deterioration of damaged wheat is checked, and any mousy taint is removed. The growth of weevils was not inhibited, nor were their eggs and the young pupæ prevented from developing. The latter problem is dealt with more fully in the second part of the bulletin, which includes a summary of reports

Fig. 1. Arab plough and cattle.

Fig. 2. Arab plough, showing detachable share.

Fig. 3. Long-handed spade a common implement with the agriculturist.

Fig. 4. Arab "Arabıyah" with a Ford car in the background.

Fig. 5. Water lift.

Fig. 6. Water lift.

SNAPSHOTS FROM MESOPOTAMIA.

received from the Government entomologists of the various States as to insects damaging grain, and a progress report of the special committee on the damage to stored grain by insects. The committee recommends the appointment of a qualified investigator for systematic research on the life-history of the weevils in Australia and the best means of dealing with them, and this proposal is at present under consideration by the Wheat Board.—[*Nature*, May 23rd, 1918.]

***

THE ORIGIN OF THE UBA CANE.

MR. NOEL DEERR writes in the *International Sugar Journal*, April 1918, as follows :—

Access to the excellent libraries in New York has enabled me to locate references which throw light on the origin of the Uba cane.

The Report of the Royal Botanic Gardens of Mauritius for 1870* gives an account of a large number of varieties of canes that were imported to that island in 1869. Amongst these importations were six varieties from Brazil, and included therein is the Uba cane. It is classed in the report as " a worthless variety."

In the *Sugar Cane* for June, July, and August, 1877, there appears a translation from the Portuguese of the report of a committee that was appointed to investigate the alleged successful grafting of the sugarcane. Frequent reference is made in this report to the Uba cane as a variety well established at that date. It can also be inferred from the report that the existence of the Uba cane in Brazil runs back for many years.

I was fortunate enough to find a copy of the very rare *De arboribus fructibus et herbis medicis atque alimentarii nascentibus in Brasilia et regionibus vicinis* of Piso, dated 1658. The description of the sugarcane begins with the words " Hæc arundo, *Viba* et *Tacomaree,* Lusitanis Canna d'Açuquare, dictâ........ " The words italicised are the native Brazilian equivalents for a reed or cane.

The same copy of Piso contained the *Tractatus topographicus et meteorologicus Brasiliæ* of Marcgraf. In the section *De armis*

* *Sugar Cane*, December 1870.

Brasiliensium the following passage occurs: "Sagittas ex arundine silvestri faciunt et vocant utramque rem uno nomine *Vuba*."

From these passages it is possible to deduce that the Uba cane found its way to Natal from Brazil *viâ* Mauritius subsequent to 1869, and that it travelled under and was known by the name of Uba. The derivation may without much doubt be ascribed to the native Brazilian *Viba* or *Vuba*, meaning a reed.

Dr. Barber has identified the Uba cane as one of the Ganna canes of India, and this identification suggests a speculation based on the argument given below, which I cannot refrain from hazarding. The sugarcane reached Europe in the ninth century A.D., and had presumably travelled there from India, with Arabic and Moslem civilization. In 1420 the Portuguese took it to Madeira and in 1506 to Brazil, the Spanish taking it to San Domingo and to the Antilles. The cane thus introduced can hardly be any other than that variety which Piso saw and described in the seventeenth century. I would therefore suggest that the native term of Viba or Vuba became attached to the only variety cultivated on the later introduction of other varieties. If this supposition is correct, then the Uba cane is none other than that which received the name of "Creole" or "Canne du pays" in the West Indies, when it became necessary to find a distinctive name for the variety cultivated before the introduction of the Batavian and Otaheite canes in the closing years of the eighteenth century.

***

A NEW PROCESS IN HAWAIIAN SUGAR INDUSTRY.

THE invention of a new process for the recovery of sucrose from final molasses, which would mean a gain of at least 3½ per cent. in the commercial sugar crop of the Hawaiian Islands, is reported by the correspondent at Honolulu of the United States Department of Commerce. The inventor is Mr. J. N. S. Williams, who is field engineer to an American firm in the Islands. The new process takes from the so-called "final molasses" approximately one-half of the 8 per cent. of sugar that heretofore has been considered an absolute loss. The additional cost for machinery will be slight, says

Mr. Williams, but in the long run it will involve no additional cost to produce $3\frac{1}{2}$ per cent. more sugar by the new process than is now taken from the juice in the production of second, third, and fourth sugars. The process, he claims, will produce in one operation what now takes three operations, and at the same time will yield the additional sugar.

Mr. Williams's experiments with this process have extended over two years. The results, as summed up, are that final molasses boiled to 99 per cent. Brix will develop small grains representing practically the whole of the sucrose present in the molasses, that this grained sucrose can be recovered in large quantities with suitable equipment, and that this recovered sucrose may be converted into a marketable product.

The principle on which Mr. Williams has worked is that it is not the glucose gums or ash, but solely the water in molasses that has prevented the sucrose therein from crystallizing. Removing the water, then, is the only method, he believes, by which it can be made to give up its sucrose. This is the first step in the process—boiling the molasses to a practically complete absence of water. The next important departure in the new process is the use of a high-speed centrifugal. On this point Mr. Williams explained that he had used a centrifugal built in 1905, which has been run to a speed almost twice as great as centrifugals ordinarily show. It is added that specially built centrifugals and apparatus for breaking the hard massecuite probably were the only machinery items on which there would be added cost.—[*Journal of the Royal Society of Arts*, London, April 12th, 1918.]

***

MANUFACTURE OF NATALITE AND OTHER CANE BY-PRODUCTS.

A COMPARATIVELY new South African enterprise is represented in the manufacture of rectified alcohol, methylated spirits, ether, and cane wax, by a cane by-products company at Merebank in Natal.

The company has a resident excise officer and a chemical expert. The works are supplied by water driven from a dam by suction

gas plant through pipes, a distance of fully 1,200 yards, into a specially constructed tank of immense storage capacity.

The original venture of the company was the extraction of the wax from the refuse of sugar mills. This product, termed mila, is in appearance like rubble. Mila is dried on the sugar estates, and then sent to Merebank, where it is put in an extractor—one of three—which is constructed in two sections, the upper part of which has a false perforated bottom. At the top is a condensor and a benzine tank combined. After a certain process the wax and the benzine pass through a side glass into the bottom chamber. Here the benzine is distilled from the wax, and at the conclusion the latter is driven off and put into moulds.

The most interesting commercial venture the company has undertaken within recent date is Natalite (or motor spirit), which, it is claimed, will probably in time largely displace petrol for driving machinery and particularly motors.

The source of Natalite's origin is treacle from the sugar estates, which is brought to the siding at Merebank, and then drained into 250,000 gallon tanks. Thence the treacle is led through pipes into mixing tanks, and then run into large vats whose holding capacity is about 10,000 gallons. Here it is fermented. Thereafter the treacle is pumped up into a receiver on the top storey, and the wash turned into a still. From this receptacle it passes into a heater, built in columnar form, and after certain automatic regulations the spirit is separated from the wash rising in the column, while the wash, known as dunder, emerges from the bottom still into a tub, whence it is carried through piping on to the company's land for fertilizing purposes. The spirit vapour passes through two copper columns and a still, in which the good spirit is separated from the best of 70 over-proof. The best is used for preparation of Natalite, the weaker for making methylated spirit. Finally, after the different qualities have been pumped into the mixing-room and dealt with, they are "racked off" in various-sized drums and tins.

The firm only commenced to manufacture ether in February. The merits of dunder as a fertilizer are said to be that though

when it is applied in liquid form plant life does not thrive, when it dries combination is formed with the earth, which is of great value in promoting plant growth.—[*The Board of Trade Journal*, April 18th, 1918.]

***

A NEW USE FOR SUGAR IN THE CURING OF RUBBER.

According to the *Philippine Agricultural Review*, a new use has been recently found for sugar by Drs. Swart and Ultee, of Java, in the curing of rubber. Heretofore acetic acid was used exclusively for that purpose, but through the experiments of the above-named scientists it has been learned that sugar acts equally as well if not better than acetic acid for this purpose, and it may be employed at greatly reduced expense.

***

GERMAN PHOSPHATE "SUBSTITUTES."

About eight years ago Dr. Hopkins, of the Illinois Experiment Station, enquired of various agricultural authorities in Europe, what proportion of the 100 per cent. increase, according to reliable statistics, in the yield of wheat and other cereals within the past century in Europe, could be attributed to various factors such as improved seed, manures, better rotation, and more thorough tillage. The replies elicited showed that about 50 per cent. of the increased outturn in Germany was due to the use of commercial fertilizers and stable and green manures. When this is considered together with the fact that, with the full pre-war supply of artificials, Germany only just managed to raise enough, or nearly enough, corn to feed her human population, the importance to Germany of the different plant-foods for the proper maintenance of the national corn crop will be manifest.

Of the three principal plant-foods, Germany is remarkably well placed so far as potash is concerned as there is unlimited supply of this material within her own borders. As regards nitrogen she has been able to provide for her wants by the fixation of atmospheric nitrogen on a large scale. The position with regard to phosphatic

manures is however different, for Germany had always in the past to rely mainly upon overseas supplies and these have now been completely cut off by war conditions. In pre-war days Germany manured her cultivated land with phosphates at the rate of no less than 33 lb. per acre, and her total consumption was 1½ million tons of basic slag and an equal quantity of superphosphates. Of this enormous quantity only half, which consisted almost entirely of basic slag, was locally available, and this too is not now so abundant. The local phosphate deposits are too crude in quality and too limited in quantity to meet Germany's needs. The fortunes of war have indeed placed in German hands certain territories in France and Belgium which can be exploited for phosphate supplies, but they are hardly abundant enough for Germany's requirements. There are known to be extremely rich phosphate deposits in Central Russia, but the recent offer of a prize by the German Government to the discoverer of new and workable phosphatic deposits not only within the limits of the German Empire but also in the occupied regions on the eastern front, is significant inasmuch as it tends to show that they have not been located. Bones are requisitioned in that country for the purpose of live-stock feeding, and the surplus available for utilization as a source of phosphoric acid is negligible. In that home, *par excellence*, of the substitute, the search for substitutes naturally began, and a writer in the *Journal of the Department of Agriculture and Technical Instruction for Ireland* (vol. XVIII, no. 3) says that "her chemists have proved no less ingenious and resourceful in the domain of artificial manures than they have been in that of foodstuffs and other commodities.

"In the midst of the host of worthless substitutes, there are, however, some which appear to have a genuine claim upon the attention of farmers. Amongst the best of the phosphatic manures placed upon the market are the 'Rhenania phosphate,' Schröder's 'phosphate-kali,' and the more recently invented 'Germania phosphate.'

"The first-named fertilizer is manufactured by the well-known Rhenania Chemical Firm in Aix-la-Chapelle. The raw material used is low per cent. crude phosphate unsuitable for making superphosphate, and double silicates such as phonolith and leucittephrit,

but more especially the former. The materials are ground up fine, mixed in a certain proportion, and brought to a white heat in large revolving furnaces such as those used for Portland cement. During the process carbonic acid is liberated, also alkaline fumes. The mass is brownish-black when cooled off and as hard as stone. It is then ground down to powder. The following table shows the result of the analysis of two samples of Rhenania phosphate.

	Sample 1. (p. c.)	Sample 2. (p. c.)
Total content of phosphoric acid	11·85	11·65
Phosphoric acid soluble in 2 per cent. citric acid ...	8·08	8·40
Ditto soluble in citrate (Petermann-Kellner test)	7·25	7·22
Total content of potash . ..	2·45	2·89
Potash soluble in water	1·01	1·30

"Experiments show that the value of the phosphoric acid in Rhenania phosphate is at least equal to that of the phosphoric acid in basic slag, and may even exceed it. As is the case with basic slag, the composition of Rhenania phosphate is very variable, but, on the whole, the new fertilizer is regarded as a valuable addition to the stock of phosphatic manures, particularly as it can be made of crude phosphates unsuitable for other purposes.

"Schröder's 'phosphate-kali', is the result of an attempt to transform the phosphoric acid in crude phosphates into a more easily soluble form. Chlorated lime and magnium chloride are heated together with crude phosphate. The liberated hydrochloric acid exerts a disintegrating effect upon a portion of the tribasic phosphate of lime contained in the crude phosphates. Practical experiments with 'phosphate-kali' showed that it may be successfully applied to cereal crops, but is less suitable for potatoes. Though these two new fertilizers are regarded as promising, it is thought that further experiments are necessary before a final verdict can be pronounced.

"Another phosphatic fertilizer which has aroused a good deal of attention is the 'Germania phosphate' manufactured by the Portland Cement Co. of Hanover. The raw material in this case is German phosphorite from the lately reopened works in the Lahn District. From this, it is said, 80 per cent. of the total content of phosphoric acid can be extracted by the application of heat. The

composition of the fertilizer is as follows: Water-soluble phosphoric acid was not present, but there was a total content of 8·7 per cent. of phosphoric acid of which 6·1 per cent. was soluble in citric acid. Of potash 6·3 per cent. was present, and of this 5·6 per cent. was soluble in water. Cultural experiments showed that while 'Germania phosphate' was superior in ome respects to 'Rhenania phosphate,' both were inferior to basic slag in respect of the results obtained."—[EDITOR.]

***

THE **"natural" or spontaneous coagulation of the latex in the production of rubber** has been attributed on one hand to enzyme action, and on the other to the agency of bacteria. Mr. M. Barrowcliff, in the *Journal of the Society of Chemical Industry* for February 15, 1918, adduces good evidence in support of the former theory. Coagulation of latex was found to take place in normal time after addition of toluol which acts as a bactericide but is non-toxic to enzymes. Similarly, the addition of thymol did not inhibit or retard coagulation. Small quantities of soluble calcium salts greatly accelerated the action, as is usual with enzymes; but hydrocyanic acid which is fatal to nearly all enzymes completely prevented coagulation. Even the "acid" process of coagulation is considered to be enzymic, the added acid functioning as an enzyme activator.—[*Nature*, May 23rd, 1918.]

***

EFFECT OF LIGHT ON HEALING OF TREE WOUNDS.

IN the Netherlands East Indies some experiments have been carried out, says the *India Rubber World*, with four-year old *Hevea* trees of equal dimensions to test the influence of light in regard to the healing of wounds. From each tree a small strip of bark and cambium was cut at a height of about five feet and the wound thus made was covered, with the exception of a small portion at the bottom, with pieces of blue, green, yellow, red, and colourless glass.

The best results were obtained with the blue and colourless glass, while yellow glass gave the worst results. It furthermore appeared that exposed wounds, from which the scrap had been

removed, healed more slowly than those over which the scrap had been allowed to remain, while these again healed more slowly than those under the colourless glass.

It would thus appear that covered wounds heal the best and most rapidly, and if this cover is transparent, the best results are obtained.

From this one could gather that the best material to apply to a wound would be some kind of transparent varnish, could this be obtained; possibly a resin oil might be suitable.—[*The Planters' Chronicle*, July 13th, 1918.]

***

MANUFACTURE OF POTATO STARCH IN NORWAY.

THE British Vice-Consul at Stavanger writes :—

A number of firms have erected factories for the production of potato starch in Norway, the factories being situated at Stavanger, Larvik, Jesnes, Lena, Levanger, and Volden.

It is understood that the process used at one of the factories is as follows :—The potatoes are first washed mechanically. They are then reduced to pulp by being pressed through a sieve of blades. The pulp is washed by a spray, and then ground between millstones, and the starch again washed out. The pulp is then dried and is eventually used as fodder. The liquid resulting in both cases is run over an incline consisting of planed boards on to which the starch is precipitated. (At one time the liquid was collected in tanks and the water drained off after the starch had deposited. As the liquid contains but a small percentage of starch, excessively large tanks were necessary.)

In order to clean the starch, it is mixed with water and allowed to precipitate. The water is drained off and the surface of the caked starch is washed with a hose and brush. This is done several times. When clean the starch is dried, first centrifugally, and then in a hot chamber.

Until the final stage is reached, the starch is apparently always kept fluid and pumped through pipes, when it is necessary to transfer it from one part of the factory to another.—[*The Board of Trade Journal*, April 25th, 1918.]

THE Report of the Departmental Committee appointed to enquire as to **precautions for preventing the danger of infection by anthrax in the manipulation of wool, goat-hair and camel-hair** has just been issued (Cd. 9057). The Disinfection Sub-Committee concludes that anthrax can only be prevented either by preventing the disease among animals or by the destruction of the organisms in the wool or hair. The Sub-Committee has devised a process for the last-named purpose, the essential features of which are :—(1) Treatment of the material with a warm aqueous solution of soap containing a little alkali, followed by squeezing between rollers; this disintegrates the blood-clots. (2) Treatment with a warm solution of formaldehyde in water and again squeezing; this destroys most of the spores. (3) Drying and standing for a short time, by which any remaining spores are killed. The Committee is of opinion that the Government should undertake the work of disinfection at a central institute or station. For the treatment of 10,000,000 lb. of wool annually, the cost of the central station is estimated to be 18,000*l*., and the working cost to be from 0·544*d*. to 0·824*d*. per lb. of untreated material. These figures were computed at pre-war prices, and about 75 per cent. would have to be added to meet present day conditions.—[*Nature*, June 13th, 1918.]

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

THOUGH somewhat belated we offer our hearty congratulations to Professor T. H. Middleton, Deputy Director-General, Food Production Department, Board of Agriculture, London, and from 1889 to 1896 Professor of Agriculture, Baroda College, who has been admitted a Knight Commander of the Order of the British Empire on His Majesty's birthday.

***

THE following appointments have been made in consequence of the grant to the Hon. Mr. R. A. Mant, I.C.S., Secretary to the Government of India, Department of Revenue and Agriculture, of one month's privilege leave with effect from 3rd October, 1918, or the subsequent date on which he avails himself of it. These arrangements are for the duration of the leave or until further orders :—

MR. J. MACKENNA, C.I.E., I.C.S., Agricultural Adviser to the Government of India, to officiate as Secretary to the Government of India, Department of Revenue and Agriculture.

Dr. W. H. Harrison, Imperial Agricultural Chemist, to officiate as Agricultural Adviser to the Government of India.

***

MR. S. MILLIGAN, M.A., B.Sc., has been confirmed as Director of Agriculture, Bengal.

***

DR. W. H. HARRISON, Imperial Agricultural Chemist, was granted privilege leave for five weeks from the 4th July, 1918, and Mr. J. N. Mukherji, B.A., B.Sc., First Assistant, was placed in charge of current duties.

***

MR. C. M. HUTCHINSON, B.A., Imperial Agricultural Bacteriologist, was on privilege leave for six weeks from the 12th August,

1918, Mr. N. V. Joshi, B.A., B.Sc., L.Ag., First Assistant, holding charge of current duties of the post during the period.

***

Mr. T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., Imperial Entomologist, was granted privilege leave for one month from 9th September, 1918, and Mr. C. S. Misra, B.A., First Assistant, placed in charge of current duties.

***

Dr. F. J. F. Shaw, Second Imperial Mycologist, has been appointed from 8th July, 1918, to act as Imperial Mycologist during the absence of Dr. E. J. Butler, M.B., F.L.S., on deputation to the Federated Malay States.

Mr. J. F. Dastur, M.Sc., First Assistant to the Imperial Mycologist, is appointed from the 8th July, 1918, to act as Second Imperial Mycologist, *vice* Dr. F. J. F. Shaw.

***

Mr. G. S. Henderson, N.D.A., N.D.D., Imperial Agriculturist, has been appointed Controller (Agricultural Requirements, Mesopotamia) under the Indian Munitions Board.

Mr. M. Wynne Sayer, B.A., Assistant to the Agricultural Adviser to the Government of India, continues in charge of the work of the Imperial Agriculturist in addition to his own duties until further orders.

***

Captain G. C. Sherrard has been appointed Deputy Controller, Agricultural Requirements, Mesopotamia, with effect from the 1st July, 1918.

***

Lieut. A. C. C. Rogers has been appointed Deputy Controller, Agricultural Machinery, Mesopotamia, with effect from the 10th May, 1918.

***

Messrs. W. M. Schutte, F. T. Newland, and F. H. Vick, Agricultural Engineers, Bombay, Madras, and United Provinces, respectively, have been appointed Deputy Controllers, Agricultural

Machinery, under the Indian Munitions Board, in addition to their own duties.

***

MR. H. M. LEAKE, M.A., B.Sc., Economic Botanist to the Government of the United Provinces and Principal, Agricultural College, Cawnpore, who, on return from leave in last July was placed on special duty at Naini Tal, resumed his ordinary duties at Cawnpore in the middle of August.

***

ON return from military duty Mr. F. J. Plymen, A.C.G.I., Agricultural Chemist, Central Provinces, is posted as Deputy Director of Agriculture, Western Circle, Central Provinces.

***

ON return from military duty Mr. J. H. Ritchie, M.A., B.Sc., is posted as Deputy Director of Agriculture, Northern Circle, Central Provinces.

***

DR. R. V. NORRIS, M.Sc., A.I.C., took charge of the office of Government Agricultural Chemist, Coimbatore, on the 22nd July, 1918.

***

MR. T. COUPER, M.A., I.C.S., Director of Agriculture, Burma, whose services were placed at the disposal of His Excellency the Commander-in-Chief, has since been given a commission in the Indian Army Reserve of Officers and is attached to the 4/70th Burma Rifles.

***

MR. D. F. CHALMERS, I.C.S., is appointed to be Director of Agriculture, Burma, *vice* Mr. A. E. English, C.I.E., I.C.S.

***

MR. E. THOMPSTONE, B.Sc., Deputy Director of Agriculture, Burma, whose services were placed at the disposal of His Excellency the Commander-in-Chief with effect from the 1st May, 1918, reverted to his civil appointment on the 26th July, 1918.

***

MR. R. BRANFORD, M.R.C.V.S., Superintendent, Government Cattle Farm, Hissar, was granted 2 months and 28 days' privilege

leave combined with 3 months and 3 days' special leave on private affairs from 28th June, 1918.

Captain R. Morris, Deputy Superintendent, has been appointed to act in Mr. Branford's place.

*
* *

MR. W. TAYLOR, M.R.C.V.S., has been confirmed in the Civil Veterinary Department with effect from the 21st March, 1918.

*
* *

THE sixth annual meeting of the Indian Science Congress will be held in Bombay from the 13th to 18th January, 1919.

His Excellency the Governor of Bombay, Baron Willingdon of Rattan, G.C.S.I., G.C.I.E., G.C.B.E., has consented to be Patron of the meeting, and Lieut.-Colonel Sir Leonard Rogers, *Kt.*, C.I.E., M.D., B.S., F.R.C.P., F.R.C.S., F.R.S., F.A.S.B., I.M.S., Professor of Pathology, Medical College, and Bacteriologist to Government, Calcutta, will be President.

The Sectional Presidents will be:

Applied Botany and Agriculture: The Hon'ble Mr. G. F. Keatinge, C.I.E., I.C.S., Director of Agriculture, Bombay.

Physics and Mathematics: Dr. D. N. Mallik, B.A., F.R.S.E., of the Presidency College, Calcutta.

Chemistry: Mr. F. L. Usher, B.Sc.

Systematic Botany: Mr. S. R. Kashyap, M.Sc., B.A.

Zoology: Mr. S. W. Kemp, B.A., Superintendent, Zoological Survey of India.

Geology: Dr. L. L. Fermor, A.R.S.M., F.G.S., Superintendent, Geological Survey of India.

Medical Research: Lieut.-Colonel W. Glen Liston, M.D., D.P.H., I.M.S., C.I.E., Director, Bombay Bacteriological Laboratory.

The local Honorary Secretaries are Mr. A. R. Normand, M.A., B. Sc., Wilson College, Bombay, and Mr. D. D. Kanga, M.A., A. I. I. Sc., Elphinstone College, Bombay. The Honorary Treasurer is Mr. R. D. Mehta, C.I.E., Calcutta. Further particulars of the meeting may be obtained from the Honorary Secretary, Dr. J. L. Simonsen, Indian Munitions Board, Simla.

Reviews.

Prussic Acid in Burma Beans.— By F. J. WARTH, B.Sc., M.Sc. and KO KO GYI. *Bulletin No. 79, Agricultural Research Institute, Pusa.* Price As. 2 or 3*d*.

THE presence of prussic acid in Burma beans and the danger arising from their use for human consumption has recently attracted the attention of London importing firms who have pointed to the poisonous character of occasional cargoes, and the suggestion was made that the Burma Agricultural Department might encourage the cultivation of non-toxic varieties. An attempt was made to meet this suggestion by importing Madagascar beans, but it was found that this strain was unsuited to the local conditions and consequently any improvement must be confined to an investigation of the ordinary Burmese crop.

The authors have studied the problem by collecting a number of single plant samples of typical beans and growing them as pure strains at three different agricultural stations situated in distinct agricultural zones and testing the produce for the prussic acid content. From the results obtained the authors draw the following important conclusions :—

(1) The content of hydrogen cyanide is an inherited character of single plant cultures. These cultures may be multiplied and will maintain the differences noted.

(2) The hydrogen cyanide present in the cultures is found to vary considerably according to soil and climatic conditions, but

(3) Cultures giving low amounts of hydrogen cyanide in one locality give low values under all the conditions tested.

(4) The best cultures so far found always contain some hydrogen cyanide, but the quantity is only half that contained in the original sample of Madagascar bean imported into the province as safe.

(5) Differences in colour in seeds from a single culture do not indicate differences in the power of producing hydrogen cyanide in their progeny.

It follows from these conclusions that by means of a careful chemical selection pure strains can readily be obtained which are quite safe for human consumption and which will retain the characteristic. The authors are to be congratulated on the results of their investigation which undoubtedly will bear fruit of great commercial and agricultural value.—[W. H. H.]

***

The Zemindar Hitkari or the Zemindar's Friend.—By Major-General His Highness the Maharaja Sir Madho Rao Scindia, G.C.S.I., G.C.V.O., LL.D. (Camb. & Edin.), D.C.L. (Oxon.). Price Rs. 6-8. Printed at the Alijah Durbar Press, Lashkar, Gwalior, 1917.

THIS book deals in considerable detail with the relations between the ryot and the zemindar, and between the zemindar and the Government; things that the Government expects from the zemindar and things that are likely to prove beneficial both to the zemindar and the ryots living in His Highness's State. There are 37 chapters dealing with such varied subjects as cultivation, irrigation and its sources, agricultural banks, destruction of *kans* grass (*Saccharum spontaneum*), planting of trees, improvement of livestock, fodder, forest rights, assessment rent, wills, education, village sanitation, seed stores, zemindar's records, etc. The book is profusely illustrated, there being no less than 116 pictures and 9 large maps and plans. Many of the pictures are of improved farm implements and machinery, and their insertion in this book indicates the interest His Highness takes in this all-important subject, which is so very closely connected with the increase in the outturn of crops and the improvement in the material condition of those who make their living from the land. We must, however, remark that it is a pity

that the illustrations are not up to the literary standard of the book. In a subject of this kind, so much can be learnt from good illustrations that they should always be most carefully drawn. We have gone through the book with considerable interest, and are struck with the wide selection of subjects dealt with by the author, which range from steam-ploughing tackle to machines for making red tape. We sincerely hope, however, that His Highness does not propose to popularize the use of these latter machines in his administration, as we have not found them of any material use in agricultural improvement!—[W. S.]

***

THE Bombay Department of Agriculture has recently issued a **Bulletin** by Mr. M. L. Kulkarni, Acting Deputy Director of Agriculture, Southern Division, **on the Utilization of Inferior Grass Herbage**, which records the results of the experiments with the spear grass as carried out on the cattle farm at Tegur in Dharwar District. In parts of the Bombay Presidency liable to partial or complete failure of rains the necessity for increasing the existing supplies of fodder, both wild and cultivated, is becoming more insistent, and the problem of getting the maximum benefit from what is available is linked up with it. There are large areas of the uncultivated spear grass (*Andropogon contortus*) in the Deccan, and the question is how to make the best possible use of it as fodder for cattle. If cut in the ordinary way when it is ripe and the spears have formed, the grass is not so nutritious, and it also injures the mouths of cattle and horses. But when the grass is cut at the time of flowering and before the spears have formed, it provides good nutritious fodder, silage and hay. Cut in flower with a grass-mower and collected with a hay rake and then siloed, it makes excellent silage. But when the cutting operations have to be deferred for some reason or other till the grass has become quite ripe it is best to use a comb of the type described in the bulletin for removing the spears. Though the weight of grass cut when fully ripe is nearly double it is inferior; yet it is fairly good and is relished by the cattle in the dry part of the year when very little grazing is available.

By the use of the methods described in the bulletin the author succeeded in keeping the cattle at Tegur in condition all the year round and in making the farm entirely self-supporting as regards fodder throughout the year at a minimum cost. These methods are practicable on a very large area, and if adopted they should remove the chief difficulty in breeding and rearing cattle in very extensive areas in the Bombay Presidency.—[EDITOR.]

***

WE have received from the Secretary to the **All India Cow Conference,** Calcutta, a copy of the **Report of the Proceedings** of the conference held there in December 1917, and we are glad that a non-official Association has been started to enlighten the public on the gravity of the situation as regards the milk supply, particularly in towns, and also as regards the general shortage of cattle in the country. It is also very commendable that the conference has decided to approach the question from an economic and not a religious or political standpoint. We have every sympathy with the objects aimed at by the conference, *viz.*, the improvement of cattle and an increase in the supply of pure milk and other dairy products. Propagandist work must be done first as public opinion requires to be educated as to the real causes of the problem. When this is done and the sympathy of the people concerned enlisted, it will be easy to devise effective measures to cope with the evil.

The root of the evil lies in the low milk yield of Indian cows. In India an average milk yield of a cow during the whole lactation period, taking the various breeds into consideration, is barely 2,500 lb. In Europe and America the figure approaches 5,000 lb., while a large number of herds of the Ayrshire and Holstein breeds give nearly 8,000 lb. and over. To improve the milk-yielding capacity of Indian cows they should be crossed with bulls of better milking strains. It may be that Montgomery or such other indigenous breed will, in some cases, be found suitable. In others we may have to import bulls from abroad, *e.g.*, Ayrshires or Holsteins.

The next point that requires attention is proper feeding. It is no use buying a good cow or bull and then starving it. While the

provision of public pasture grounds, if feasible, is good in that they act as an exercise ground for cattle, they are also very fertile sources of mischief. Here nondescript cattle mix together, immature bulls are allowed to roam with the result that breeding becomes promiscuous, and contagious diseases are easily communicated to the whole herd. With a view to keep the cattle in condition all through the year, it is advisable that the growth of fodder crops, like maize, *jowar* (*A. Sorghum*), guinea grass, berseem, etc., should be taken up in earnest. In Europe farmers and stockbreeders feed roots to cattle and some portion of a farmer's land is usually set aside for growing root crops. The present practice in some parts of this country of simply allowing cattle to shift for themselves or giving them *bhusa* and other bulky fodder requires to be supplemented by a ration of oil-cakes, pulses or other concentrated foods in reasonable quantities.

The third evil is that bulls not required for purposes of breeding are not castrated in this country. The result is that immature bulls often serve the cows when they go out in the village common. It is most essential that the farmers should be made aware of the ruinous consequences of the practice resulting in degeneration of the breed.

As regards general shortage of cattle in the country, we think that if more care is taken of young stock so as to render them more serviceable for work, and if proper nutrition is given to bullocks, they will be able to do a good deal more work than they do at present and the shortage will not be so seriously felt. We also think that the bullock should not remain the only motive power in India. In numerous places the introduction of mechanical appliances will not only relieve the bullock power but also be more economical. We are emphatically of opinion that if Indian agriculture is to hold its own and the economic condition of India is to improve she should use more mechanical appliances than she is doing at present.

Government Departments are fully alive to the seriousness of the problem and, by providing good bulls, supplying prophylactics, opening dairy and cattle-breeding farms, as well as by encouraging co-operative dairies and the like, are trying to grapple with the

problem, but the people have not yet quite realized the necessity of taking extra care and trouble in the matter of stock-breeding. It requires to be brought home to them that it pays to devote attention to details such as purchasing a good animal, feeding it properly, mating it with a suitable sire, taking proper care of calves, and keeping the animal in fit condition when dry. A little more cleanliness in the production and handling of milk also will be amply repaid. If the conference succeeds in interesting people in this question and arousing their enthusiasm and in enlisting the support of wealthy people for the opening of model dairy farms outside large cities, the pace of the work which the Department is already doing will be considerably accelerated.—[EDITOR.]

Correspondence.

THE PROBLEM OF SUGAR MANUFACTURE IN INDIA.

To the Editor,

The Agricultural Journal of India.

Sir,

In view of the importance of the necessity for solving the problem of sugar manufacture in India before the termination of the war in order that there be no recurrence of the blunders which have been made throughout the country in erecting *gur* refineries which have proved failures and are largely responsible for the backward state of the sugar industry, I trust you will kindly allow me further space in the *Agricultural Journal* for the attached letter on "Sugar Development in Mysore," which appeared in a recent issue of the *Madras Mail*, and also for the following further comments I have to make on Mr. Wynne Sayer's letter which appeared in the last issue of the *Agricultural Journal.*

Mr. Wynne Sayer writes as follows :—

"Any improvement in this line (putting a stop to the enormous wastage—some 30 to 50 per cent.—which now goes on in *gur*-making) will increase the *gur* production ; part of this may take the place of the molasses now imported from Java, the rest will tend to glut the *gur* market and will make more *gur* available for refining."

Now, the molasses imported into India from Java and Mauritius for the purpose of manufacturing spirit is the by-product or exhausted molasses of cane sugar factories which manufacture sugar direct from the cane, and for raw sugar (*gur*) to be made in India to take the place of this molasses would be against all the laws of economics, as sugar is much more valuable than when converted

into a material, molasses, for the manufacture of spirit which it is necessary to do before the raw sugar could be used for spirit manufacture; and, further, to advocate the utilising of the raw cane sugar for making spirit, as has been done in several distilling concerns when molasses were not available in order to carry out Government spirit contracts, is to advocate the growing of sugarcane simply for the purpose of making spirit. Surely this must appear to be absolutely wrong to anyone giving due consideration to the matter. As for the suggestion that the surplus *gur* would be available for refining, I can only say that I have pointed out, over and over again, that the refining of cane *gur* is not a profitable business, and it would be the height of folly for anyone to erect a *gur* refinery, when there are so many examples of failures of such concerns in, I may say, nearly every province in India.

Even in the United Kingdom, in Greenock, Leith, Liverpool, London, etc., the refineries that refined the raw sugar imported from the West Indies were obliged to close, as they could not compete with the Continental beet-root sugar factories which manufactured direct from the beet-root juice without any double manufacture; and if any development of the Indian sugar industry is to take place, it is essential that the losses of sugar in manufacture be reduced to the minimum, and this can only be done by avoiding the manufacture of *gur* and making the sugar direct from the juice, the exhausted molasses going to a distillery or utilized for the manufacture of molasscuit or tobacco or golden syrup. There must be no Hobson's choice about the matter.

The idea of putting down a *gur* factory in the centre of the cane cultivation and fitted with triple crushing mills, Krajewski crusher, triple effect evaporator, vacuum pan and such machinery as is used in sugar factories, simply for the purpose of making *gur*, must appear absurd, when it is considered that a refinery attempting to refine the product would be a failure unless it was turned into a distilling business; and it must appear to be more absurd still when it is considered that with some additional machinery to the suggested *gur* factory, such as sulphurous acid gas plant, clarifiers, eliminators, filters, crystallisers and centrifugals, a commercial

white cane sugar, such as is imported from Java and Mauritius, could at once be turned out profitably without having to put up a *gur* refinery which would be a failure.

When criticizing Mr. Wynne Sayer's article, I did not overlook the fact that in the United Provinces and Bihar which produce much *gur* the product does not rank as eating *gur* and sells at Rs. 2-8-0 per maund to refineries; but instead of that proving it is only suitable for refining, it merely proves the reverse and shows that the canes from which this inferior quality of *gur* is made, and which are grown by the ryots without proper manuring or any attempt at scientific cultivation, are not good sugar-making canes. The *gur* is consequently more suited to manufacturing spirit than sugar, and so it is that it is purchased largely by *gur* refineries having distilleries attached to them, such as the Cawnpore Sugar Works. Other *gur* refineries in the United Provinces and Bihar, at Unao, Cawnpore, and Saran, without distilleries, have had to close down.

In order to develop the sugar industry in the United Provinces, it is essential that a better variety of cane be grown, and cane sugar factories, not refineries, established; and in this respect I beg to quote as follows from the report of the Tenth Meeting of the Board of Agriculture, which appeared in the last issue of the *Agricultural Journal*.—"Dr. Barber's claim that the problem of producing the seedling suitable for North Indian conditions, under which the largest area of sugarcane lies, is in a fair way to being solved, was borne out by the series of seedlings which were exhibited in the Board's room. It is easy to realize the immense importance of this success, if it fully materializes on the development of a really healthy sugar industry in this country." This healthy sugar industry, which is so much desired, can only be brought about by attention being given, in the first instance, to the extracting of the maximum quantity of sugar, *not spirit*, from the canes, and this cannot be done by making *gur*.

Certainly, as Mr. Wynne Sayer remarks, improved methods of *gur* boiling make for a larger recovery of sugar; but no improvements in the direction of *gur* manufacture will ever get over the fact

that a *gur* refinery will not pay, and the more *gur* that is made by the ryots, instead of resulting in a large increase in the outturn of sugar and a consequent reduction in the imports from abroad, will result in the ruin of the Indian sugar industry and the absolute impossibility of any development ever taking place; and this was fully realized by the United Provinces Government when the small model cane sugar factory was brought out from home and demonstrated working at the Allahabad Exhibition.

In my letter to which Mr. Wynne Sayer replies, I advocated for the ryots the use of oil engines for driving small power mills in preference to employing machinery which is only used in large sugar factories under the supervision of skilled European engineers, as being more suited to the ryot for making *gur* for eating purposes, and beyond this the average ryot should not attempt to go. If he were to employ small steam plant for the purpose, he would find that the refuse crushed cane would not be sufficient for boiling his juice, as well as for keeping up the necessary steam pressure in the boiler for driving his mill, and that he would also require to purchase auxiliary fuel in the shape of wood or coal, as in numerous instances the ryots have to use wood fuel in addition to the crushed cane for boiling the juice only. Mr. Wynne Sayer confuses the working of a large factory which, when economically designed, runs on the megass only as fuel, and then with boilers having specially constructed furnaces, with a small *gur*-making plant in which the crushed cane is neither suitable nor sufficient as fuel.

In preference to the ryots making *gur* to such an extent throughout the United Provinces, it would be better if, in selected cane-growing centres, the larger ryots be got to co-operate and establish even a small factory to produce, say, 3 tons of sugar daily for local consumption, or capable of dealing with from 200 to 300 acres of cane per season. Such factories could easily be designed for extension and could grow along with the cultivation, and they would require to be under the supervision of a sugar engineer employed by Government at least for a time. Where a large acreage can be taken up by a company, it is a different matter, as then a large factory can be put down right away.

In concluding my correspondence in the *Agricultural Journal* on this important subject of the sugar industry, to which I have given considerable study, and in which I have had considerable experience in India and other sugar-producing countries, I would point out that the reports of the different sugar companies given by Mr. Wynne Sayer in no way bear out his contentions, for the simple reason that the abnormal high price of sugar prevailing owing to the war enables these companies to make profits which they could not do before the war.

It must also be remembered that (1) The Cawnpore Sugar Works, which refine the cane *gur*, have distilleries attached for converting the large quantity of molasses produced into spirit; (2) The Champaran Sugar Co., Ltd., is a cane sugar factory and manufactures sugar direct from cane and not from *gur*; (3) The Ryam Sugar Co., Ltd., is the old *gur* refinery at Sakri that was a failure before the war. All these companies are now run by the same firm of managing agents and are not examples to go by, for it must be borne in mind that if the sugar industry is to be developed, the factories must be of such a design that will enable them to compete with imported sugar and to earn profits after the war.

CUMBALLA HILL, BOMBAY: Yours faithfully,
April 25, 1918. A. E. JORDAN.

P.S. A most important point which must also be remembered is that the erection of *gur* factories for making *gur* on a large scale would result in the killing of the cottage *gur* industry, as the ryots could not compete with such factories, and I take it that Government is not desirous of bringing this about.

A. E. J.

COPY OF MR. JORDAN'S LETTER TO THE *MADRAS MAIL*.

Considerable interest is now being taken in the developing of indigenous industries in the Mysore State and, among the various industries it is possible to develop with advantage to the State,

it is to be hoped that special attention will be given to the sugar industry with a view to establishing a properly designed factory in order to pioneer what should be the State's chief agricultural industry. It has been shown by Government experts that the sugar-cane grown in Mysore is second to none in the world as a good sugar-making cane, yet, notwithstanding this, there is not a single cane-sugar factory at work in the whole of the State, and enormous wastage goes on year after year through jaggery only being made, and for the most part in the crudest possible manner. There is no doubt but that there is a large demand for good jaggery for eating purposes—a demand which it is necessary should be met; but there is also room for considerable improvement in the way of more economical methods of making the jaggery than that usually employed, whereby a better extraction might be obtained from the canes by employing more powerful crushing mills and a better quality of jaggery produced by employing more improved methods of boiling the juice. To effect this object, the writer, some years ago, introduced into the Mysore State the first powerful cane-crushing mill of its kind for driving by either oil or steam engine, and suitable for cultivators having from 50 to 100 acres of cane cultivation. This small mill, during experiments carried out by Dr. Lehmann, late Agricultural Chemist to the State, crushed 1 ton of sugar-cane per hour and gave an extraction of 75 per cent. of the juice. Since its introduction but little progress, if any, has been made regarding jaggery manufacture, owing to the lack of interest taken in the matter; but there can be no doubt but that the wider introduction of such mills, along with more improved boiling pans and furnaces as are employed at the Manjri Government Farm near Poona, would be of considerable benefit to the cultivators who at present employ bullock-driven mills. With regard to the manufacture of sugar, several abortive attempts have been made to establish a profitable sugar factory in the State—the one claiming most attention being the jaggery refinery at Goribidnor on the Madras and Southern Mahratta Railway. This refinery was originally established in 1893 by Messrs. Arbuthnot of Madras for the purpose of refining the cane jaggery which is made extensively

in the surrounding districts—but, like others of its kind in different parts of India, it could not be made a commercial success, owing to the wrong methods of sugar manufacture employed. This refinery, through which Arbuthnot's firm lost heavily, had not been long working when the difficulties of obtaining large supplies of cane jaggery at a cheap rate were experienced—and on the Mysore Government being approached, a concession of 5,000 acres of land was given to enable cane to be grown, the idea being to convert the jaggery refinery into a cane-sugar factory, but the failure of the house of Arbuthnots put an end to further progress in this direction. The refinery was then taken over by the South Indian Industrials—several further attempts to run it profitably as a jaggery refinery have also resulted in failure, and the refinery now stands as an object-lesson in the Mysore State to show how sugar should not be made. At the Conference of the Agricultural Board recently held in Poona, Dr. C. A. Barber, the Government Cane Expert, stated that there appeared to be more prospect of improved methods being opened up as regards sugar manufacture in Mysore, and it is now left for the State to revive this important industry; and now that H. H. the Maharaja is taking a personal interest in the developing of the State industries, some substantial progress may be looked for in the near future. The developing of such an important industry as the sugar industry will have far-reaching and most beneficial results, for, by the establishing of sugar factories, the State would derive a revenue from the manufacture of rum, as a distillery could be attached to the first or second factory for manufacturing a wholesome spirit from the waste molasses. Sugar factories and sugar estates would give employment to labour which heretofore has emigrated to other countries in order to do similar work; the position of the ryot in the vicinity of the factories would be vastly improved, as he would be able to send his cane to the factory and thus be freed from the cares and anxieties incidental to the manufacture and sale of jaggery for a refinery which can only pay him a low price for his product. The young men of Mysore would have opportunities of learning mechanical and sugar engineering which they cannot do at colleges, finding congenial employment in the

factories and on the estates—and Mysore might in time become not only self-sustaining in the matter of sugar production, but an exporting State as well.

Mr. SAYER'S REJOINDER.

To the Editor,

The Agricultural Journal of India.

Sir,

I must confess that my last reply to Mr. Jordan was possibly too brief, which has apparently led to some misapprehensions regarding the question of *gur* factories and refineries, and I will now endeavour to make it perfectly clear. The case is as follows :—

The manufacture of sugar, whether it be from beet or cane, is a highly technical industry, involving chemical control at every stage, and best carried on in large factories capable of applying to the industry all the resources of the chemist and the engineer. Everywhere, except in India, primitive methods have given place to centralization on a large scale. This is what we must aim at here and attain, or ultimately go to the wall, and the problem which has to be faced is, how to steer the cane-grower through the transition stages. Few ryots grow any large area of sugarcane, and usually the cultivation is carried on in small patches. The methods of manufacturing *gur*, as at present adopted by the ryots, are very wasteful, and the interests of the cultivators as well as consumers, and the Indian sugarcane industry itself, require that the two functions, *viz.*, the raising of the crop and its conversion into *gur*, which are now in the hands of the cultivators, should be separated. The ryots would then devote their attention to what they really understand, *viz.*, better cultivation of their crop, and the manufacturers will specialize in the most efficient methods of extracting the largest amount of juice from the cane and boiling and evaporating it under the most favourable and economical conditions.

There are many areas in India which will not carry a sugar factory large enough to hold its own in open competition. The cane cultivation in these areas is limited by the fact that the growers cannot

manage to deal with any more cane with their existing bullock power and appliances. By putting up a *gur* factory they will be relieved from this difficulty, and as it undoubtedly pays them to sell their cane to a *gur* factory, they will increase their land under this crop. Until the area becomes large enough to carry a sugar factory which will be large enough to pay, it is preferable to confine ourselves to *gur* factories in such tracts. Such an evolution does not, in my opinion, result in the "ruin of the Indian sugar industry, and the impossibility of any development ever taking place," to quote Mr. Jordan's words.

I disagree entirely with Mr. Jordan's idea of putting up these small 3 tons a day white sugar factories. The percentage of management and replacement expenses chargeable to each maund of sugar manufactured by such a factory are bound to be far higher than in a large factory, and competition will kill them; this has been the rule the whole world over in most industries, and I do not think India is going to prove any exception to the rule. I leave out of consideration those small factories which were enabled to make a profit by producing Swadeshi sugar, for which their customers were willing, out of sentiment, to pay a higher price. Sentiment cuts no ice in open competition, and is not a foundation on which you can put down a factory in these days of rate-cutting competition.

Now, accepting the fact that we have these *gur* factories, **so long as the majority of the Indian population use *gur*, either for eating or cooking, there will be a big market for it, and it will always pay to manufacture on a factory scale.** What are we to do with the surplus, supposing that it was a record cane year? The *gur* market would be very low from over-production, and the result would be that a large number of people, who formerly did without *gur* owing to its price, would be able to buy it; regular buyers and users would also increase their consumption as *gur* will oust sugar in many things once the price of good *gur* falls below that of sugar. This extension of the demand would deal with a portion of the surplus, and the question of the remainder is where Mr. Jordan and I cannot agree. I maintain that such a surplus can be refined, and that it is in no

way "against all the laws of economics," as Mr. Jordan thinks. The old trade rule is that if you have a surplus you have got to dump it somewhere, and I think we have learnt that lesson pretty thoroughly from America and the Continent. The surplus *gur* having been manufactured in a factory under proper conditions will refine into *more than* 40% sugar, the rest being molasses. The alternative is to throw it out, and I have not the least doubt which alternative would be accepted by the manufacturers. The molasses left after this refining could and would take the place of the Java molasses which arrive in India at Rs. 1-12-0 per maund, have to pay 10% import duty, and railway freight, and cannot get anywhere near such molasses as the above when produced from *gur* at a cheap figure. Only one or two *gur* refineries would be necessary, and whether they should have spirit contracts or not attached to them is a matter for later consideration. I have dealt with it in my article "The Problem of Sugar Manufacture in India." Anyhow, they could produce ethyl alcohol or sell for molasscuit or for curing tobacco.

May I ask Mr. Jordan to read carefully pages 557 and 558 of my article in the October (1917) issue of this Journal, where I think I made it pretty clear that **I did not favour *gur* factories at the expense of sugar factories.** I fully emphasized the necessity of establishing white sugar factories on up-to-date lines—where the cultivation would carry them; unless a factory is capable of turning out at least eight tons of white sugar a day it will not be able to stand the competition of Java and Mauritius and this presupposes that it is obtaining its cane from a district where there is no competition from a large factory. In parts where the price of *gur* is usually low, or where orthodox people are prepared to pay a little more for sugar manufactured within the country on account of its being free from suspicion as to the use of animal bone char for refining it and where the demand is almost at the very door, the establishment of small sugar factories is justified as it tends to reduce the imports to that extent. Such factories in their off season should either refine *gur* where it is available at cheap rates in large quantities or should have an oil-crushing plant attached to them so that the establishment and management expenses charged on the production

of sugar may be as low as possible. But where *gur* generally sells dear and the price of cane is correspondingly high we think the line of advance is in the creation of up-to-date *gur* factories. Such factories by avoiding all possible waste will add to the country's production of *gur*. In this way we will not only provide for the country's requirement of this commodity but also enable these same factories with a few additions to be converted later into sugar factories when the cultivation round about has increased sufficiently to carry them. I will now pass on to deal with the remainder of Mr. Jordan's letter paragraph by paragraph.

In paragraph 4 Mr. Jordan refers to the closing down of the refineries in England, and maintains that their process was apparently unsound, because they could not compete with the Continental factories manufacturing direct from beet juice. Possibly Mr. Jordan has been over the beet factory established in England, at Cantley in Norfolk, before the war, in which a Dutch company, I think, was heavily interested; but if, as I suspect, he has not, possibly a few details as to the subsidy of these Continental factories by their Governments might enlighten him. It was the stimulus supplied by the Governments concerned that led to investment of large amounts of capital and vast improvements in the quality of beet and the methods of manufacture. Add to this the heavy subsidies given, and the home market assured to these factories, and you will easily account for the ruin of the British refineries, and the Cantley concern quickly found out how differently the English Government treated its sugar manufacturers. Continental factories also used to get a fancy price for their dried beet slices. I was told that the German Government used to pay even up to £6 a ton for these slices for army use. The value of them for cattle food was certainly not one-third of that price, and it was by obtaining fancy prices for such by-products from Government, and by Government subsidies, that they smashed the English refineries. Mr. Jordan forgets that dumping under subsidy will ruin the soundest manufacturing business in the world if it cannot hold out—but this does not prove the above business to be unsound in its working, for the dumpers will never go on dumping when they have destroyed the competition,

but will put up prices to the rate at which the original competitors were selling.

In paragraph 5 Mr. Jordan forgets that the tract in which such a *gur* factory would be put up would not carry a white sugar factory successfully in the face of competition. I never stated that such a factory would be only for refining. The principal product it would turn out would be *gur* for direct consumption.

Turning to paragraphs 6 and 7, I hardly think that Mr. Jordan's statement that the canes of the United Provinces and Bihar are such that they produce *gur* which is only fit for spirit-making, proves that sugar cannot be profitably made from them. Sugar has been profitably made from them for a good many years before the war, and will continue after the war. I quite agree better canes are wanted, but this is a slow job. The *deshi* cane is hardened to most things; it may not be a good sugarcane, but you are safe with it against a total loss of cane, which might occur if the district suddenly plunged into the unacclimatized varieties.

Paragraph 7. I thank Mr. Jordan for his quotation. I can hardly allow that it refutes me, as I wrote it myself holding the same ideas as I do now.

In paragraph 8 Mr. Jordan refers to the white sugar factory which was worked at the Allahabad Exhibition. If it was a success, why aren't such going now? The truth is it was not, and that for the reason I have given above, *viz.*, its manufacturing expenses were too high to enable it to exist in the face of competition, and neither Mr. Jordan nor any other of its advocates can get past that fact.

Paragraph 9. My answer is that the *gur* factories I advocate are not intended for the average ryot. They are either capitalistic or co-operative concerns, able to deal with the cane of some 250-500 acres during the working season. Such a factory would run by steam on megass with very little extra fuel if any.

In areas which cannot carry even a *gur* factory, the system adopted on the Manjri farm is of course the most suitable.

In thanking Mr. Jordan for his criticisms, and in concluding this correspondence, I would add that the reports of the factories I quoted went to strengthen the point which I emphasized in my article " that

the present is the most favourable time for devising measures to put the Indian sugar industry on a satisfactory basis, as Indian sugar is now being made under most favourable conditions, and this state of things, which gives an insight into the possibilities of the industry in India when foreign competition is lacking or curtailed, will not last for long, and if the industry which is now in places getting its head above water is allowed to be stifled again by unfair competition, it will not readily respond to efforts made in the future to resuscitate it"; and I in no way here meant to refer to the success of *gur* refineries. A broad outlook is what is urgently required, and there is ample room in India for work on all the three lines of white sugar, *gur* and the Manjri type of crusher without their ever hindering each other. The main point is that it is now or never for this industry. "Wait and see" is not a suitable motto in this case.

PUSA : Yours faithfully,
June 17, 1918. WYNNE SAYER.

[The correspondence on this subject is now closed.—EDITOR.]

MOTOR CULTIVATION.

TO THE EDITOR,
The Agricultural Journal of India.

SIR,

Regarding the article headed "Notes on Motor Cultivation" in the July Number of *The Agricultural Journal of India* (vol. XIII, p. 537), I cannot help thinking that the writer has exaggerated the case for the double engine cable system of ploughing, and certainly the figures given cannot be used as an argument in the case of Indian agriculture.

Firstly, there is no reason why, for a given horse-power, the double engine cable system should plough ten times as many acres as the motor tractor at half the cost per acre! Further, in this country there is a question of fuel and water to be considered, which is a serious item. In your July article it is stated that two skilled men and four unskilled men are sufficient for one double steam engine set. However, extra labour would in most cases have to be employed to carry the feed water from the nearest wells and to keep the engine

bunkers supplied with fuel. In the case of a motor tractor, the extra men could be dispensed with, as the quantity of water required for cooling the cylinder or cylinders would be comparatively small, for the kerosine motors run best at a temperature of about 200° F., and an appreciable quantity of fuel can be carried on the tractor with a further supply placed in a convenient position on the farm.

With regard to the running expenses, the motor tractor, I think, scores heavily when threshing, cutting, sawing of wood, running pumps, and other farm work is considered. An unskilled native can handle a kerosine engine far more economically than a steam engine ; further, for a given horse-power the efficiency of a kerosine engine running comparatively light is higher than that of a steam engine, and this is an item to be considered in cases where engines run for any length of time on perhaps half load. Of course there are some motor tractors on the market that are really unpractical, but makers within even the last two years have had good experience in constructing these machines from an engineer's and the farmer's point of view, and after they learn a few more lessons from their own and their neighbour's faults, I am confident that we shall have on the market a low-priced thoroughly reliable motor tractor suitable for the Indian farmer. Unfortunately British agricultural engineers have not had an opportunity to study this question during the last four years on account of their time being occupied solely in connection with the war. However, when hostilities cease and time can be devoted to this branch of engineering, there is no reason why the internal combustion engine should not replace the steam engine in agriculture, as it is doing now in the case of stationary power plants and locomotion.

I hope at a future date to be in a position to supply you with detailed working costs of a farm of about 1,000 acres worked by a motor tractor of perhaps 30-60 H.P., and judging by rough figures which I already have, the working costs per acre will show a considerable saving if compared with the double engine cable system of ploughing, etc.

BOMBAY :
August 7, 1918.

Yours faithfully.
M. BRADY.

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS.

1. Fungi and Disease in Plants, by E. J. Butler, M.B., F.L.S., Imperial Mycologist, Pusa. (Calcutta and Simla: Thacker. Spink & Co.) Price Rs. 15.
2. Soil Physics and Management, by Professor J. G. Mosier and A. F. Gustafson. Pp. xiii+442. (Philadelphia and London: J. B. Lippincott Co.) Price 8*s*. 6*d*. net.
3. Veterinary Post-Mortem Technic, by Professor W. J. Crocker. Pp. xiv+233. (Philadelphia and London: J. B. Lippincott Co.) Price 16*s*. net.
4. The Science of Power, by Benjamin Kidd. Pp. 306. (London: Methuen & Co., Ltd.) Price 6*s*. net.
5. The Third and Fourth Generation: An Introduction to Heredity, by E. R. Downing. Pp. xi+164. (London: Cambridge University Press.) Price 1 dollar net.
6. Plant Products and Chemical Fertilizers, by S. H. Collins. Pp. xvi+236. (London: Baillière, Tindall & Cox.) Price 7*s*. 6*d*. net.
7. The Alkali Industry, by J. R. Partington. Pp. xvi+304. (London: Baillière, Tindall & Cox.) Price 7*s*. 6*d*. net.
8. Equipment for the Farm and the Farmstead, by Professor H. C. Ramsower. Pp. xii+523. (Boston, Mass., London, etc.: Ginn & Co.) Price 10*s*. 6*d*. net.
9. Plant Physiology, by Professor V. I. Palladin. Authorised English Translation, edited by Professor B. E. Livingston. Pp. xxv+320. (Philadelphia: P. Blakiston's Son & Co.)

10. Flora of the Presidency of Madras, by J. S. Gamble. Part II. (London: Adlard & Son & West Newman, Ltd.) Price 8*s*. net.

11. L'Evolution des Plantes, by Professor N. Bernard. Pp. xxxii +314. (Paris: F. Alcan.) Price 3·50 francs.

12. A Text-book in the Principles of Science Teaching, by Professor G. R. Twiss. Pp. xxvi+486. (London: Macmillan & Co., Ltd.) Price 7*s*. 6*d*. net.

13. The Young Observer's Handbook, by W. P. Westell. Pp. 317. (London: McBride, Nast & Co., Ltd.) Price 7*s*. 6*d*. net.

14. An Introduction to the History of Science, by Professor W. Libby. Pp. x+288. (London: G. G. Harrap & Co., Ltd.) Price 5*s*. net.

15. Field Book of Insects, by Professor F. E. Lutz. Pp. ix+509. (New York and London: G. P. Putnam's Sons.) Price 12*s*. 6*d*.

16. Studies in Electro-physiology (Animal and Vegetable), by A. E. Baines. Pp. xxix+291. (London: G. Routledge & Sons, Ltd.) Price 12*s*. 6*d*. net.

17. Practical Organic and Bio-Chemistry, by R. H. A. Plimmer. New and Revised Edition. (London: Messrs. Longmans, & Co.) Price 18*s*. net.

18. Rural Reconstruction in Ireland, by Lionel Smith Gordon and Lawrence C. Staple. (London: P. S. King & Son.) Price Rs. 7-8.

19. Cellulose: An Outline of the Chemistry of the Structural Elements of Plants with Reference to their Natural History and Industrial Uses, by Cross and Bevan. New Impression, with Supplement. Pp. xviii+348. (London: Longmans, & Co.) Price 14*s*. net.

20. Foods and Their Adulteration, by Harvey W. Wiley, M.D., Ph. D., Chief of Bureau of Chemistry of the U. S. Department

of Agriculture, Washington. (London: J. and A. Churchill.) New (3rd) Edition. Price 24*s*. net.

21. Forecasting the Yield and the Price of Cotton, by Professor H. L. Moore. Pp. vi+173. (London: Macmillan & Co., Ltd.)

22. Applied Bacteriology, edited by Dr. C. H. Browning. Pp. xvi+291. (London: H. Frowde & Hodder & Stoughton.) Price 7*s*. 6*d*. net.

23. Rubber: Its Production, Chemistry, and Synthesis in the light of Recent Research, by A. Dubosc and Dr. A. Luttringer. English Edition by Edw. W. Lewis. (London: Charles Griffin & Co.) Price 21*s*. net.

24. Sugar from Several Points of View, by George Martineau, C.B. (London: W. M. Clowes & Sons.)

25. A Short History of Science, by Professor W. T. Sedgwick and Professor H. W. Tyler. Pp. xiv+474. (London: Macmillan & Co., Ltd.) Price 12*s*. 6*d*. net.

THE following publications have been issued by the Imperial Department of Agriculture in India since our last issue:—

Memoirs.

1. Studies in Indian Sugarcanes, No. 3. The classification of Indian canes with special reference to the Saretha and Sunnabile Groups, by C. A. Barber, Sc.D. (Botanical Series, Vol. IX, No. 4.) Price Rs. 2-4 or 3*s*.

2. "Heart Damage" in Baled Jute, by R. S. Finlow, B.Sc., F.I.C., F.C.S. (Chemical Series, Vol. V, No. 2.) Price R. 1 or 1*s*. 6*d*.

3. Experiments on the Improvement of the Date Palm Sugar Industry in Bengal, by Harold E. Annett, B.Sc., F.I.C.; Gosta Behari Pal, M.Sc.; and Indu Bhusan Chatterjee, L.Ag. (Chemical Series, Vol. V, No. 3.) Price R. 1 or 1*s*. 6*d*.

Bulletins.

1. Insecticides, Mixtures and Recipes for use against Insects in the Field, the Orchard, the Garden, and the House, by H. Maxwell-Lefroy, M.A., F.E.S., F.Z.S. (Bulletin No. 23, Reprint of the Second Edition revised by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S. Price As. 8 or 9*d*.
2. Berseem as a New Fodder Crop for India, by G. S. Henderson, N.D.A., N.D.D. (Bulletin No. 66, Second Edition.) Price As. 2 or 3*d*.
3. Sugar and the Sugarcane in the Gurdaspur District, by J. H. Barnes, B.Sc., F.I.C., F.C.S. (Bulletin No. 69.) Price As. 14 or 1*s*. 3*d*.
4. New Agricultural Implements for India, by G. S. Henderson, N.D.A., N.D.D. (Bulletin No. 73, Second Edition.) Price As. 2 or 3*d*.
5. Prussic Acid in Burma Beans, by F. J. Warth, B.Sc., M.Sc., and Ko Ko Gyi. (Bulletin No. 79.) Price As. 2 or 3*d*.
6. The Value of Phosphatic Manures in India and the Possibility of their Manufacture on a Larger Scale. Being evidence submitted to the Committee appointed to discuss this question (Subject IX) at the meeting of the Board of Agriculture, Poona, 1917. Edited with an Introduction by W. A. Davis, B.Sc., A.C.G.I., Chairman of the Committee. (Bulletin No. 81.) Price As. 4 or 5*d*.

Indigo Publications.

1. Present Position and Future Prospects of the Natural Indigo Industry, III. The Future of Natural Indigo in India, by W. A. Davis, B.Sc., A.C.G.I. (Indigo Publication No. 2.) Price As. 10 or 1*s*.
2. The Loss of Indigo caused by Bad Settling and the Means of Obviating this. The use of Dhak Gum—Its Effect on Yield and Quality, by W. A. Davis, B.Sc., A.C.G.I. (Indigo Publication No. 3.) Price As. 4 or 5*d*.

PREFACE.

THE Fifth Indian Science Congress met at Lahore in January 1918. The Agricultural Section was presided over by Dr. L. C. Coleman, Director of Agriculture, Mysore, and this special issue of the *Agricultural Journal of India* contains a selection of the papers bearing on agriculture and allied subjects read at the Congress. It is impossible to publish all the papers read on account of limitation of space.

The lecture by Messrs. Howard and Hole dealing with Recent Investigations on Soil-aeration will appear in the *Indian Forester*, and will also be published in subsequent numbers of the *Agricultural Journal of India* together with the following papers :--

(1) Some problems arising out of the successful introduction of American Cotton in the Western Punjab, by W. Roberts.

(2) Beginnings in insect physiology and their economic significance, by S. K. Sen.

(3) Coconut: The wealth of Travancore, by Dr. Kunjan Pillai.

(4) "Northerns" Cotton, by G. R. Hilson.

(5) Manures in their relation to soils and crop production in the Central Provinces, by D. Clouston.

(6) The improvement of "Tinnevellies" Cotton, by R. Thomas.

(7) The sun-drying of vegetables, by G. L. C. Howard.

The paper on Bacteriotoxins in Soils, by Mr. C. M. Hutchinson, will be issued as a Memoir; while Mr. B. H. Wilsdon's paper on the Need and Objects of Soil Surveys in the Punjab and Mr. D. Milne's on the Improvement of Cotton in the Punjab will appear as Bulletins of this Department.

I am indebted to His Honour Sir Michael O'Dwyer, the Patron of the Congress, for his kindness in allowing his photograph to appear as frontispiece to this Number, while my acknowledgments are also due to the Asiatic Society of Bengal, under whose auspices the Indian Science Congress is held, for permission to publish the papers contained in this issue *in extenso*.

J. MACKENNA,

Agricultural Adviser to the Government of India.

PUSA:
May 12*th*, 1918.

HIS HONOUR SIR MICHAEL FRANCIS O'DWYER, G.C.I.E., K.C.S.I.,
Lieutenant-Governor of the Punjab.

INDIAN AGRICULTURAL DEVELOPMENT.*

BY

LESLIE C. COLEMAN, M.A., PH. D.,

Director of Agriculture in Mysore.

THE development of agriculture in India has formed the subject of an interesting and valuable report[1] by Mr. Mackenna which no doubt all of you have read. That report shows quite clearly that the Agricultural Departments in India have already justified the broad-minded policy inaugurated by Lord Curzon, through the increased returns which they have enabled and are enabling the Indian agriculturists to obtain from their land. It is, therefore, unnecessary for me to attempt an apologia for organized agricultural work in this country even were I competent to provide one. It might, however, be profitable for an unofficial scientific body such as the Indian Science Congress to examine the means which are being utilized to improve Indian agricultural conditions and to consider in how far those means are calculated to lead to permanent results. It would, I think, also be well within our province to point out certain dangers which lie ahead and to suggest means for avoiding them.

The two lines of work which appear to have yielded the most striking tangible results during the past ten years are :—

(1) The improvement of the staple crops of the country by selection and the organized distribution of the improved seed obtained ; and

* Presidential Address delivered before the Agricultural Section of the Indian Science Congress, Lahore, January, 1918.

1 Mackenna, J. " Agriculture in India," 1915.

(2) the transfer of the best indigenous methods of cultivation and the best indigenous implements as utilized in certain areas to other more backward parts of the country.

The reasons why these two lines of work have produced tangible results so rapidly are fairly obvious. In the first place, neither demands on the part of the agriculturist an expenditure of money or labour greatly in excess of that which he has been accustomed to devote to the cultivation of his land. In the second place, neither requires, under the present conditions of low production which prevail in this country, very long or very accurate experimental work to enable agricultural experts to satisfy themselves as to the suitability of their introduction. The various Departments of Agriculture in India have been quick to appreciate these facts, and we find to-day in many provinces as much time and money being devoted to growing and distributing improved seed and to popularizing efficient indigenous agricultural practices and implements as on all the rest of the strictly agricultural work put together. I do not wish it to be thought that I consider plant-breeding as a kind of experimental work which requires less careful scientific control than others. I wish only to emphasize the fact that in a country such as India, where scientific work in connection with agriculture dates back hardly more than twenty years, improvement by selection is comparatively easy and plant-breeding work in India has up to the present been mainly confined to selection. Hybridization has been rarely resorted to. We have, it is true, the work of the Howards on wheat, Leake's work on cotton, and Barber's work on sugarcane, all of which are rich with promise for the future, but the improved varieties of crops which are being distributed on such a large scale in Madras, the Central Provinces, the United Provinces, the Punjab, and Bengal are, in practically all cases, the result of selection. As time goes on we shall no doubt find ourselves in the same position as the countries of Europe, when an immense amount of the most careful and painstaking scientific work will be required to evolve a type which is distinctly better than those already

being grown, but we have not yet reached that stage of development.

As so much emphasis has been placed on plant-breeding during the past few years, it will be interesting to enquire just what are the probabilities of improvement in this direction. About eight years ago Dr. Hopkins of the Illinois Experiment Station sent a circular letter to various agricultural authorities in Europe, including such well-known men as Hall, von Seelhorst, Schneidewind, and Wagner, pointing out that, according to reliable statistics, the average yield of wheat and other cereals had increased in Europe by about 100 per cent. within the past century and enquiring what proportion of this increase could be attributed to each of the following four factors :—

(1) The use of improved seed.
(2) The use of plant food in commercial fertilizers and stable and green manures.
(3) Better rotation of crops.
(4) More thorough tillage.

The authorities consulted, while differing somewhat in their views, were practically agreed that the use of better seed had not provided more than 20 per cent. of the total increase in production. It will be interesting to compare with this estimate the results which have been obtained with certain crops in India. In parts of the Central Provinces, selected *roseum* cotton yields about 25 per cent. more than the mixture previously grown. Pusa 12 wheat gives an increase of from 10 to 25 per cent. in certain definite areas of the United Provinces, Bihar, and the Punjab, but unfortunately no very definite figures are available. The most striking results thus far obtained are perhaps those of Hector in Bengal, who has been able to isolate a strain of paddy yielding 30 per cent. more than the ordinary varieties grown by the ryot. From these examples, and I think they are fairly representative, it would appear that plant-breeding promises to do rather more for the Indian ryot than it has done for the European farmer. It is, however, pretty certain that this work alone will be of little permanent benefit unless it is

accompanied by improvements along other lines. In fact it may be argued with a certain amount of plausibility that plant-breeding work by itself is, in many parts of India, likely to lead to permanent harm rather than to permanent good.

How, it may be asked, can such an opinion be supported? It is hardly necessary to repeat here the view which has been so frequently expressed that we have had in many parts of India for centuries a state of agricultural equilibrium. The soil is generally very poor, and the ryot uses on it very little manure. The crops he harvests are correspondingly low, and the varieties or mixtures of varieties which he grows are no doubt nicely adapted to the existing conditions. If we now isolate strains, which, in the first instance, yield us 20 per cent. or 30 per cent. more than the varieties or mixtures of varieties usually grown, this will result in an increased drain on the soil, and unless such a drain is counteracted by an increased return of plant foods to the soil we are likely to find, in a comparatively short time, the yield from these improved strains sink back to or below the level from which we started and to discover that the soil itself has been further impoverished. We are, no doubt, still too ignorant of the processes which are going on in the soils of India, and more especially of the biological factors which influence plant production, to speak with certainty on this point, but signs are not lacking that something similar to what I have foreshadowed is likely to occur. It should be noted, however, that the above remarks refer particularly to such crops as cereals and oil-seeds, where an increase in yield represents a definite increase in the plant food taken from the soil. In the case of such a crop as cotton, where increase in yield may result from an increase in ginning percentage, the amount of plant food removed from the soil should be approximately the same whether the old mixture or the improved strain is grown.

I do not wish to be understood from these remarks as intending to belittle the value to Indian agriculture of plant-breeding and the distribution of improved varieties. There is, however, a danger that the very striking results which have been obtained from this kind of work within the past ten years will make both scientific

workers and the general public in India blind to the immense importance of other problems which face us, problems which, in many cases, will require the most patient and painstaking investigation by highly trained research workers for their solution. I shall return to this subject later and shall, in the meantime, turn to some of the other problems awaiting us.

The question of the conservation, improvement, and utilization of our manurial resources is a subject which has not received that amount of attention which it deserves. From the time of Voelcker onward we have had warnings with regard to the serious drain which the export of oil-seeds and bones has had upon our soils. The attention of the Board of Agriculture in India has been turned towards this question many times, but that body has not been able to reach any very satisfactory conclusions. Prohibition of export is a measure which seems too drastic and even the imposition of an export duty would be certain to meet with serious, if not insurmountable, opposition. The present, however, when a practical prohibition of export exists, is a most favourable opportunity for popularizing the use of these valuable products of Indian soils. We all trust that the conditions which have forced the present prohibition upon us will never recur, but it would, I submit, be almost criminal negligence on our part if we did not make the best use of the opportunity which it affords. The popularization of the use of oil-cakes as cattle foods and manures seems to me a matter of urgent importance. In this connection I may mention that an extensive campaign for the popularization of oil-cake as a manure for sugarcane is being organized in Mysore State, and, if the success already achieved can be taken as a guide, we should see within the next five or six years practically the whole of our oil-seeds being utilized for the improvement of our own soils. I anticipate that through manurial improvements alone an increase in our sugar yields of one hundred per cent. will be effected within the next ten years.

This, however, is only one of the manurial resources which have to be considered. The knowledge of our resources of mineral manures, more especially of phosphates, is very incomplete, nor

has Government taken up seriously the question of exploring them thoroughly or of utilizing them to the best advantage. Finally, the question of the fixation of atmospheric nitrogen—a question which is engaging the attention of Europe, America, and Japan to an ever increasing extent—has scarcely been touched in India. Recently the Government of Mysore has taken up this question in connection with the development of the natural water power resources of the State, and there are prospects that a factory for the fixation of nitrogen on a fairly large scale will be started in the near future. The effect that a cheap and adequate supply of nitrogen would have on the returns from most of our staple crops is almost incalculable. Lastly we have the question of green manures, and we must confess, I think, that we have still a very long way to go before we can tell ryots how best to utilize these important improvers of soil fertility. The fact that at present, in some parts of India at least, more than fifty per cent. of the nitrogen content of the green manure is lost and thus never becomes available for soil improvement, indicates clearly enough what an important field of investigation we have here.

The question of the utilization of oil-seeds and other forms of commercial manures is, as has very frequently been pointed out, intimately bound up with the question of the amount of capital which the ryot has available. It is also closely connected with the education of the agricultural population, for a proper use of commercial manures presupposes a fairly high degree of intelligence.

As regards the question of capital, there is strong evidence that the condition of the Indian agriculturist has considerably improved during the past few years, and there is undoubtedly an increasing tendency for him to spend money on the cultivation of his land. This, we believe, is partly due to the efforts of the Agricultural Departments in India. That a demand for commercial fertilizers is beginning to arise among the ryots of India was an opinion generally accepted by the Board of Agriculture at their recent meeting in Poona. The influence of the co-operative movement is also increasing rapidly, and its effect upon the economic condition of the agriculturist during the next twenty years is bound to be enormous.

Turning to education, the demand for compulsory primary education is becoming more and more insistent. The number of schools in rural areas is increasing rapidly, and, provided our rural education is conducted on rational lines, it will lead to an awakening of the Indian agricultural population which is bound to have the most beneficent effect upon the development of our greatest industry. I have used the expression "on rational lines" with a purpose, for there seems to me the gravest danger that we shall, in India, commit the same mistakes which have been committed in other parts of the world and shall find the sons of our agriculturists leaving school with a distinct distaste for the occupation upon which the future prosperity of this country depends.

In the past, agricultural workers in India have been in the difficult position of having to justify their existence to two separate bodies. On the one hand, they have had to prove to an at-times-somewhat-critical Government not only that the work they were endeavouring to do was likely to lead to practical results commensurate with the money which was being expended upon it but also that the results obtained warranted the expenditure of very much larger sums of money. On the other hand, they have had to persuade a conservative agricultural population that improvements on existing methods were not beyond the bounds of possibility. Both these difficulties have been, to a most gratifying extent, surmounted, and signs are not wanting that ere long we shall be landed in the opposite difficulty of being over-powered with demands for a guidance which we are not able to furnish.

What do we require to fit us in the best possible way to meet the emergency which I have foreshadowed? We need above all things a much larger and better organized research staff. Any one who has studied carefully the reports of the various Agricultural Departments, and more especially the reports of experimental farms, must realize that much of the experimental work which is being attempted is not likely to be of more than ephemeral value. This is more especially the case with regard to manurial experiments. All the experience of Europe goes to show that the most important increases in crop production have come as a result of the scientific

use of manures. Germany is to-day able to feed herself largely because of her use of commercial fertilizers, and she has been taught how to use them to the best advantage through the immense amount of accurate experimental work which has been carried out on stations scattered all over the country. How much of this accurate experimental work do we find being done in India at present? Many of our experimental farms are scarcely worthy of the name because there is not sufficient scientific supervision and because there is, in too many cases, a demand that the farm shall show at the end of the year a favourable balance sheet. I am not prepared to assert categorically that an experimental farm which shows a profit stands thereby condemned of masquerading under a false name, but I am prepared to assert that if the time of the farm staff and the land on the farm are devoted, as they should be, to accurate experimental work, such a farm cannot be worked at a profit. The desire of the general public to see the results of experiments rather than the processes by which those results are obtained is a natural one. It should be satisfied by the only rational method, namely, demonstration on special farms or on the fields of cultivators. An experimental farm should be looked upon as an out-door laboratory, not as a model or demonstration. There may be room on it, as there is in a chemical laboratory, for rough qualitative tests, but to stop with these, as I fear too many of our farms have done in the past, is fatal to permanent progress. That we have not suffered more as a result of this foolishly economical policy is due to the fact that we have, for the most part, been dealing with fairly simple problems for which the approximate results obtained have furnished information upon which recommendations could be made with some degree of safety. As time goes on such approximate results will become steadily less useful, and unless we have substituted accurate experiments for the crude methods which now only too frequently obtain we may find ourselves in the unfortunate position of having to give to the ryot when he asks for bread, not a stone perhaps, but half-baked dough.

The question of research and experimental work is a pressing one. As I have already pointed out, the introduction of improved

varieties is not likely to take us very far unless it is followed up by improvements in manuring and cultivation. An improved variety does, however, give the agriculturist an incentive towards better methods of treating his land, because it shows him that there are possibilities of increased profit from agriculture outside of those furnished by a rise of prices. The moment it becomes apparent that a crop will repay better soil treatment the question of just what treatment is soundest economically becomes one of the first importance. The questions which arise in connection with this subject are as many and varied as are the soils and climatic conditions of India, and require the most careful investigation not only at one or two special research institutes but also at a large number of experiment stations scattered all over this broad land and manned by thoroughly trained officers who are filled with a zeal for accurate scientific work. I strongly dissent from the view one sometimes hears expressed that observations in the field can in any way take the place of accurate experiment or that fewer precautions to avoid error are required in the case of agricultural than, for instance, chemical investigations.

In our work we are, I think, being tempted (I was about to say, being compelled) to confine ourselves to problems of the immediately practical character. This is no doubt largely due to the very small number of men engaged in agricultural investigations. It is also, I fear, partly due to our being afflicted to a certain degree with the shortsightedness which has landed the British Empire on the brink of disaster. If agricultural workers in India do not themselves insist upon the importance of fundamental investigation work even when such work does not hold out prospects of returns in the near future, we are hardly likely to find governments and the general public viewing such matters seriously. There was a time and not so many years ago when an insistence upon the importance of research might have been looked upon as a sort of lame excuse for failure to produce results of practical value. That time is, I think, past, and if we now fail to lay foundations deep and broad for the future development of agriculture in India we shall stand convicted by those who come after us of a criminal neglect of duty.

IMMUNITY AND DISEASE IN PLANTS.

BY

E. J. BUTLER, M.B., F.L.S.,

Imperial Mycologist.

PLANTS, like men, vary greatly in their liability to disease. Not only do we find, in both cases, individuals that can pass unharmed through epidemics, but still more often we find racial differences in susceptibility. It is quite common amongst plants for a race or variety to be much more resistant to attack by a given parasite than other races or varieties of the same plant.

Before considering more closely the circumstances which influence susceptibility to disease, it is necessary to define what is meant by immunity. By complete immunity is meant total resistance to infection. Such complete immunity to a parasite is rare amongst plants. We have a case in India in the cotton known as *buri*, which can be grown without loss of a single plant under conditions in which every plant of other varieties of cotton is killed by wilt, a disease prevalent in the Berars and caused by a hitherto undescribed fungus of the genus *Fusarium*, which lives in the soil. Much more common is relative immunity or relative resistance to infection, where the plant gets attacked by the parasite but the attack is mild as compared with that on less resistant kinds.

Even though a plant is not truly resistant, it may escape injury in other ways. It may avoid the parasite, or it may endure an attack without suffering material damage. We must therefore distinguish between the avoidance of disease, the endurance of disease, and true resistance to disease.[1]

[1] Orton, W. A. "The development of disease-resistant varieties of plants." *IVe Conférence internationale de Génétique*, Paris, 1911, p. 249.

Plants may avoid disease in various ways. There are many parasites which are closely dependent on climate and seasonal conditions for their growth, and, with regard at any rate to our more common crops, it may be said to be a fairly general rule that cultivated plants are less closely dependent on such conditions than their parasites. Thus it is often possible to grow a crop under conditions which its parasites cannot stand, and we have many such cases in India. One was described by Dastur [1] in a paper presented at our last meeting, in which he pointed out that the common potato blight is unable to flourish in normal years on the plains of India, though endemic in the hills. Its temperature limits are too low for it to survive the heat of the plains, unless introduced from the hills after the beginning of the cold weather, an event that seems to have only occurred two or three times in the last twenty years. Even when thus introduced, it is only able to damage a single season's crop, and is then killed out by the following hot weather. Another case is the smut of *jowar* (*A. Sorghum*), caused by *Sphacelotheca Sorghi*, which ranks as one of the worst diseases of crops in India, causing a loss of probably more than a million sterling every year in Bombay alone. This disease is rare in the Gangetic Plain, owing to the fact that the temperature is too high in that area to permit its spores to germinate at sowing time. The spores are carried on the grain and infect the young seedling within a few days of germination. Experiments at Pusa and Poona show that the spores germinate best between 70° and 80°F., which is lower than the normal temperature at sowing time in the Gangetic Plain. Then there are several diseases found only in the north-west of India, though the crops attacked extend through a large part of the country. One is bunt of wheat, which is extremely destructive in Kashmir and is found in the western and submontane Punjab, but not elsewhere in India. Its spores germinate best at 60° to 65°F., which is below ordinary sowing temperatures for wheat in all but the extreme north-west. Another somewhat different

[1] Dastur, J. F. "Conditions influencing the distribution of potato blight in India." *Agric. Journ. India*, Special Science Congress Number, 1917.

It is necessary at this stage to consider a little more closely what is meant by infection. When a parasite attacks a plant we are able often to distinguish two stages in the process. The first is the stage of penetration, that is the actual entry of the parasite into the tissues. The second is the establishment of parasitic relations between the parasite and its host, which means really the obtaining of suitable food for its development from the tissues of its host. It is perfectly possible for a parasite to force an entry into a plant on which it is unable to feed and consequently to grow. Some of the rusts, for instance, will enter all sorts of plants, but once inside, they die, unless they happen to be on the plant which they ordinarily inhabit.[1] From the other plants they are unable to obtain food of the sort required for their growth, or else meet with some barrier inimical to their growth. The wheat mildew (*Erysiphe graminis*) will germinate on a leaf of barley, and will even force a sucker into the outer layer of leaf cells just as it does on a wheat leaf. But whereas in the wheat cell the sucker remains turgid and absorbs enough food to enable the parasite to continue its growth and form new suckers, on barley, under ordinary circumstances, it cannot get suitable food from the cell, and it shrivels and dies.[2]

It is frequently the case that immunity due to anatomical characters of the host plant depends on conditions which prevent the first stage of infection, namely, penetration, while immunity which is due to physiological characters depends on conditions which do not interfere with penetration but prevent the second stage of infection, the setting up of parasitic relations between the fungus and its host.

Most of the cases where immunity depends on anatomical characters are thus connected with the condition of the surface layers of the plants. For instance, there are many fungi which can only enter a plant through the breathing pores or stomata of green

---

[1] Gibson, Miss C. M. "Notes on infection experiments with various *Uredineæ*." *New Phytologist*, III, 1904.

[2] Salmon, E. S. "On the stages of development reached by certain biologic forms of *Erysiphe* in cases of non-infection." *New Phytologist*, IV, 1905.

parts, and the chances of a plant escaping infection by one of these will be influenced by the number and other characters of the stomata. Coffee leaf disease usually starts on the under surface of the leaf, as there are few stomata on the upper surface. In this case, infection generally occurs while the leaf is turned over by the wind, or is still partly folded in the bud with its under surface turned outwards so as to be easily reached by spores deposited from the air. Sometimes the size of the stomata is important, as in the beet leaf spot caused by *Cercospora beticola*. Immature beet leaves are practically immune, because their stomata are small and incapable of opening widely enough to admit the germ-tubes of spores germinating on their surface.[1] Certain varieties of plums have been shown to be resistant to brown rot caused by *Sclerotinia cinerea*, because the stomata early become plugged with masses of small parenchymatous cells. In the more susceptible varieties, penetration through the stomata is not impeded in this manner.[2]

In a few cases, the surface of a plant is not easily wetted, and fungi that depend on the deposit of films of water on the green parts for their germination may fail to secure a footing. Thus it has been noticed that the more waxy varieties of raspberries and grapes are least damaged by *Coniothyrium*,[3] and that barley in which the amount of bloom has been increased by growth in alkali soils may have its resistance to rust heightened.[4]

The number of hairs on a leaf may also influence resistance to attack. Potatoes with small, hairy leaves and an open habit of growth dry quickly after wetting and are less liable to blight than other kinds.[5] Hairs also seem to save the under surface of apple leaves from infection with the scab fungus, *Venturia inæqualis*, while the allied *Venturia pirina* readily attacks the smooth under

[1] Pool, V. W., & McKay, M. B "Relation of stomatal movement to infection by *Cercospora beticola*." *Journ. Agric. Res.*, V, 1916.

[2] Valleau, W. D. "Varietal resistance of plums to brown-rot " *Journ. Agric. Res*, IV, 1915.

[3] Appel, O "Disease resistance in plants." *Science*, n. s , XLI, 1915. Istvanffi, G. v. "Études sur le rot-livide de la vigne." *Ann. Inst. Centr. Ampélo. Roy. Hongrois*, II, 1902.

[4] Freeman, E. M "Resistance and immunity in plant diseases." *Phytopathology*, I, 1911.

[5] Appel. *l.c.*

surface of pear leaves.[1] The very hairy leaves often found in buds are sometimes noticeably immune to fungus attack.

In a few cases, structural or morphological peculiarities of a variety are of considerable importance in connection with liability to disease. Thus wheats with very open glumes are more liable to loose smut, *Ustilago Tritici*, a fungus that infects through the flower, than those of a close habit. In some varieties of pears an open channel is left from the calyx to the carpels, and these varieties suffer much from the attack of *Fusarium putrefaciens*, a fruit-rotting organism.[2]

With regard to the inner tissues of plants, which the parasite only reaches after penetration has been successfully accomplished, structural characters occasionally take part in checking an attack. Thus in several of the cereal smuts, infection may be successful up to a point but ultimately fails unless the parasite reaches the growing point of the seedling within a limited period of time, which seems to vary with different varieties of the crop. The hyphæ can only penetrate the tissues while these are still young and undifferentiated, and they may be trapped in the lower part of the primary shoot unless they get past the primary node before its vascular tissue develops. When thus trapped they soon die.[3] There are many other cases in which age influences the receptivity of the tissues, and though some of these are doubtless physiological and depend on the characters of the living parts of the cells, others probably depend on the nature of the non-living walls and are therefore anatomical. For instance, plums often get increasingly liable to brown rot as they ripen, owing to a natural softening of the middle lamella between the cells, which enables the parasite to force its way through the tissues more rapidly than before softening takes place.[4] It must not be forgotten that parasitism in fungi is in its essence an enzymic activity: the fungus usually

---

[1] Ducomet, V. "Recherches sur le développement de quelques champignons parasites à thalle subcuticulaire." Thesis, Paris, 1907.

[2] Appel. *l.c.*

[3] Lang, W. "Zum Parasitismus der Brandpilze." *Jahresber. Verein. f. angew. Bot.*, X, 1913.

[4] Valleau. *l c.*

dissolves its way through the tissues by means of enzymes produced from the tips of its threads; and since these enzymes vary from fungus to fungus and usually act each on only a single type of wall, it is evident that the successful growth of the fungus may be greatly affected by the characters of the walls of the host cells.

External conditions sometimes modify the anatomical characters which influence the resistance of a plant to disease. It has already been mentioned that the amount of bloom on barley leaves may be raised by growing in alkali soil, with an accompanying decrease in damage by rust. In pink disease of rubber, caused by *Corticium salmonicolor,* the attack is often most marked on the shady side of the trees, and it seems probable that the thinner cork of shaded parts offers a lesser resistance to penetration. Both moisture and shade affect the tissues in a somewhat similar manner, leading to fewer hairs, a thinner cuticle, and relatively less sclerenchyma, so that the increased susceptibility of densely growing crops is probably in part due to the greater ease with which their tissues can be penetrated. But it must not be forgotten that such conditions also modify the cell contents, and the thin walls of etiolated plants are due to physiological changes which modify metabolism and are accompanied by a diminution in sugars, protein, and volatile oils in the cells.[1] Hence the loss of resistance may be in part due to physiological causes, and the more we examine such cases, the more important becomes the physiological side of the question.

So far we have considered some of the circumstances which help a plant to avoid attack by a parasite, those which enable it to endure a successful attack, and those anatomical characters which produce a true resistance to attack. All of them are fairly easy to understand, and it is generally possible to specify the character concerned and to see clearly how it acts. There remains the consideration of the physiological characters of a plant which affect its resistance to parasitic attack. These are much more obscure and are the least understood as well as certainly the most important of the factors controlling immunity. They depend, so

[1] Duggar, B. M. "Physiological plant pathology." *Phytopathology*, I, 1911.

far as we know, entirely on the nature of the cell contents, and are independent of the anatomical structure of the plant or the nature of its cell walls.

A few instances which will establish the existence of this class of factors may be given. I have already mentioned that barley leaves are ordinarily immune to the attack of the mildew, *Erysiphe graminis*, from wheat. But the immunity can be broken down by immersing the leaf in warm water, touching it with a hot knife, exposing it to the vapour of ether, chloroform, or alcohol, and in other ways.[1] Maize smut (*Ustilago Zeæ*) is confined normally to those parts of the plant where the cells are young and still capable of division. But by exposing the plant to the vapour of ether, or heating it to 70°C., much more extensive infection can be obtained.[2] Again it is possible to check the growth of the cereal rust fungi even after they have become well established in the tissues, by modifying the nutrition of the plant. Cutting off infected leaves, starving the plant by reducing the supply of carbon-dioxide or mineral salts, or heating or cooling the roots, will check an attack.[3] It is obvious that exposure to ether vapour or temporary starvation cannot rapidly modify the anatomical structure, and the change in resisting power must be due to some alteration in the cell contents.

What are the cell contents which are of importance in immunity ? In the first place, they may be the living substance, the protoplasm itself. We know that it is of the utmost significance to many fungi whether the organic food offered to them is living or dead. The whole of the saprophytic fungi require their food to be dead before they can utilize it. On the other hand there are large groups of parasitic fungi that, so far as we know, cannot make any use of dead food. Not a single one of the rust fungi, of which there are several thousands of species known, has ever been cultivated

---

[1] Salmon, E. S. "Further cultural experiments with 'Biologic Forms' of the *Erysiphaceæ*." *Ann. of Bot.*, XIX, 1905.

[2] Ray, J. "Etude biologique sur le parasitisme : *Ustilago Maydis*." *Comptes rendus*, 136, 1903, p. 567.

[3] Ward, H. M. "Recent researches on the parasitism of fungi." *Ann. of Bot.*, XIX, 1905.

on artificially prepared food, and the same is true of many other species. Now it has been actually proved that the immunity of certain plants to some of their parasites is really due to hypersensitiveness. The parasite attacks the first cells it reaches too vigorously, kills them, and is soon surrounded by a ring of dead cells beyond which it cannot pass. In the non-immune sorts it enters the cells and only takes a certain amount of food from them, without killing them, before it has had time to grow on and reach fresh living cells. This sequence of events has been observed in the rusts and in the *Venturia* scabs of apple and pear.[1] In other cases it seems that there is some quality of the protoplasm which impedes the growth of the fungus, and it is this quality, whatever it may be, that is destroyed by ether and the other substances or conditions mentioned above as lowering the resistance of immune plants. What these qualities of the protoplasm are is not known, nor whether there exists in plants anything approaching the antibodies found in the blood ot animals and man, which can impede the growth of a parasite.

Then there are the non-living parts of the cell contents, substances which for the most part occur dissolved in water to form the cell sap. Of these, two seem to be specially important from our point of view : tannin, and organic acids such as tartaric, malic, citric, and the like.

Tannin is of very frequent occurrence in vegetable cells. Very occasionally it can be used as food by fungi, but as a rule it is distinctly toxic to them, and this toxic action is in general more marked on parasites than on saprophytes. The mechanism by which plants seem to make use of the toxicity of tannin in resisting fungus attacks is somewhat complex. In the living cell, in some cases at least, there is formed first an enzyme, which acts on gallic acid preexisting in the cell, to form tannin or a tannin-like body equally toxic. The power of producing this enzyme varies at different

[1] Ward, *l. c.* Stakman. "Relations between *Puccinia graminis* and plants highly resistant to its attack." *Journ. Agric. Res.*, IV, 1915. Wiltshire, S. P. "Infection and immunity studies on the apple and pear scab fungi (*Venturia inæqualis* and *V. pirina*)." *Ann. Applied Biology*, I, 1915

stages of growth. In beans, for instance, the enzyme decreases from the seedling stage until the flower buds form when it increases, then decreases again as the fruits set, rises as the latter reach full size, and finally falls as they ripen off. Now in the bean these variations correspond with the susceptibility to the disease called anthracnose, caused by *Colletotrichum Lindemuthianum*. So also in many fruits (apples, pears, persimmons, etc.) the enzyme is less in the ripe than in the green stage, and all these fruits are notoriously liable to various ripe rots which develop at full maturity but are rare on unripe fruit. In all cases the fungus is readily inhibited in its growth by tannin, and the susceptibility to ripe rots has been found to vary inversely with the power of the plant to form the oxidase which starts the toxic reaction.[1]

As regards organic acids, the evidence indicates that resistance to disease in many cases is due to a greater acidity of the cell sap, but in a few to a lesser, as compared with non-resistant varieties of the host plant. In the black rot of the grape-vine, caused by *Guignardia Bidwellii*, the resistance of certain varieties and parts of the vine has been correlated with the lesser amount of tartaric acid contained in their sap as compared with non-resistant varieties or parts. Those varieties that are rich in acid and form sugars late, as the "Folle blanche," are less resistant than those with little acid and early sugar-formation, like the "Clairette." It is known also that the leaves are only susceptible while they are young and rich in tartaric acid, while as they mature the acid diminishes and they become immune. In the same way the fully ripe grapes, which have lost most of their acid, are not susceptible. The fungus has been grown in culture and found to prefer an acid medium, being arrested by alkalis and retarded by sugars.[2]

In the grey rot of the vine, caused by *Botrytis cinerea*, the opposite is the case, as here it has been noted that the best preventive

[1] Cook, M. T., & Taubenhaus, J. J. "The relation of parasitic fungi to the contents of the cells of the host plants." *Delaware Agric. Expt. Stat. Buls.* 91 and 97, 1911-12.

[2] Viala, P., & Pacottet, P. "Sur la culture du black rot." *Comptes rendus*, 138, 1904, p. 306.

is to grow those varieties that give an acid must, like the Italian "Raboso di Piano."[1] It has been established that this fungus is repelled by certain acids found in plants.[2]

The resistance of vines to oidium and mildew has also been correlated with the acidity of the cell sap. The average acidity of leaves and must of the more resistant kinds tested (expressed in terms of tartaric acid) was from 3 to 5 times that of the non-resistant varieties.[3]

It has also been observed that the branches of lemon attacked by gummosis contain less acid than those of healthy plants, and that the less acid lemon fruits stand long journeys badly, being more readily attacked by rotting organisms than the highly acid kinds.[4]

The resistance to parasites of the hard wheats (macaroni, rivet, spelt, and Polish) is generally higher than that of common wheat. In these kinds there is relatively more glutin and less starch, more organic acid and less sugar in the sap.[5] In Italy, a wheat strongly resistant to rust known as Rieti has been examined in some detail. It has been found to have a more acid sap than that of any of the other, less resistant, kinds tested under the same conditions. Furthermore this wheat loses its resistance to some extent when grown in warmer localities than its native area, and this loss of resistance is accompanied by reduced acidity of the sap.[6] Wheat rust has never been cultivated artificially, as previously mentioned, so that its behaviour to acids is not directly known, but another wheat parasite, *Leptosphæria herpotrichoides*, is known to require an alkaline reaction in culture and to be arrested by acids.[7]

---

[1] Sannino, quoted in Comes, O. "Della resistenza dei Frumenti allo Ruggini." *Ann. R. Scuola Agric. di Portici*, XII, 1914, p. 455.

[2] Massee, G. "On the origin of parasitism in fungi." *Phil. Trans. Roy. Soc*, B, 197, 1904.

[3] Averna-Sacca, R. "L'acidita dei succhi delle piante in rapporto alla resistenza contro gli attacchi dei parassiti." *Stat. Sper. Agrar. Ital.*, XLIII, 1910.

[4] Comes. *l. c.* pp. 435 and 450.

[5] *ib.* p. 451.

[6] *ib.* p. 466.

[7] Fron, G. "Contributions à l'étude de la maladie du pied noir des céréales." *Ann. Sci. Agron. Française et Etrangère*, 4e Ser., I, 1912.

In general, the cultivated varieties of a plant are more susceptible to parasites than the wild stock from which they originated. This is noticeably the case in fruit trees, and in these the wild sorts are practically always richer in acid than the cultivated. In sugarcane too the thin canes of northern India, which are the most nearly related to the wild Saccharums, are relatively immune to certain parasites of the pith, but whether this is connected with higher acidity of the juice is not clear.

That there are other cell contents of importance besides those mentioned is probable. Sugar has been often suspected of a considerable influence, but as it usually varies inversely with the acid content it is possible that the latter is really concerned. Thus I have shown that the red rot fungus, *Colletotrichum falcatum*, is present in infected canes from sowing time but usually only develops severely as the cane matures. I attributed this to the increase in sugar, but it may equally well be due to a decrease in acid.[1]

In some cases neither tannin nor organic acids influence immunity. In potato tubers resistance to *Phytophthora infestans* is a property of the living tissues, but attempts to connect it with the reaction of the cell juices or the tannin content have failed.[2]

It will be seen that the direct proof that resistance to disease depends on single constituents such as tannin or acids is still wanting. The evidence given above is mostly circumstantial. This is partly due to the intrinsic difficulty of estimating accurately small differences in the composition of the cell contents, and also probably to the processes concerned being complex as in the case of the tannin-formation mentioned above. That the changes concerned are subtle is evident, since it is known that resistance to one disease does not imply resistance to another,[3] that different parts (such as the leaves and tubers of potatoes) may vary in their resistance,[4]

---

[1] Butler, E. J. "Fungus diseases of sugarcane in Bengal." *Mem. Dept. Agric. India, Bot. Ser.*, I, No. 3, 1906.

[2] Jones, L. R., Giddings, N. J., & Lutman, B. F. "Investigations on the potato fungus: *Phytophthora infestans*." *U. S. Dept. Agric., Bur. Pl. Indus. Bul.* 245, 1912.

[3] Orton. *l. c.*

[4] Jones, Giddings, & Lutman. *l. c.*

and that physiological resistance can be affected by a large number of external conditions.

Amongst the latter, climate, soil, nutrition, and the like, have been shown sometimes to have a marked influence.

It is fully established that immunity in one locality does not necessarily mean immunity to the same disease in another locality. In India it has been found that wheat resistant to rust in one place, may be attacked in another. At the famous wheat-breeding station, Svalöf, in Sweden, several introduced varieties were badly attacked, though almost immune under other conditions.[1] So also in South Africa, an Australian rust-resisting wheat remained exceptionally immune at Pretoria, but was much damaged in the low country.[2] In the United States a wilt-resisting watermelon lost its resistance as it was moved west towards the Pacific coast.[3]

Soil conditions also have sometimes a marked effect. Alder trees in Germany suffer more severely from the parasite, *Valsa oxystoma,* when growing in meadow land than in the swampy soil which they prefer.[4] Larch canker is worst on calcareous soils and rare on siliceous.[5] So also the oidium and mildew of the vine are said to be more prevalent on soil rich in lime than in sandy loam, because the acidity of the sap is reduced by the former,[6] and several other cases are known where an excess of lime predisposes to disease. On the other hand, those varieties of Iris that prefer a limestone soil are liable to be severely attacked by *Heterosporium gracile* when grown in soil deficient in lime.[7]

As regards nutrition, there is a great deal of evidence that resistance to disease can be materially affected by the amount and quality of the plant food supplied. Thus in a paper which will

[1] Nilsson-Ehle, H. "Kreuzungsuntersuchungen an Hafer und Weizen, II." *Lands. Univ. Arrskrift,* 2nd Af., VII, 1911.

[2] Pole Evans, J. B. "South African cereal rusts." *Journ. Agric. Science,* IV, 1911.

[3] Orton. *l. c.*

[4] Appel, O. "Ueber bestandweises Absterben von Roterlen." *Naturw. Zeit. f. Land-u. Forstwirt.,* II.

[5] Ducomet, V. "Pathologie végétale," p. 62.

[6] Averna-Sacca. *l. c.*

[7] Ramsbottom, J. "Iris Leaf-blotch." *Journ. R. Hort. Soc.,* XL, 1914-15.

be read at this meeting,[1] Mr. Finlow has shown that the resistance of jute to *Rhizoctonia* can be much increased at Dacca by manuring with water-hyacinth ash, a substance rich in potash. I also have observed that complete immunity to this disease can be induced by exceptionally heavy doses of mixed manures, but the particular ingredient concerned, whether potash or something else, was not recognizable. At Pusa, on the other hand, the no-manure plots of the permanent experiment series are relatively free from *rahar* (*Cajanus indicus*) wilt, caused by *Fusarium udum*, as compared with some of the manured plots. The figures this year, for instance, are :—

Manurial Series.

No-manure plot: deaths up to 20th December, 1917	12
The three superphosphated plots respectively	1035, 1194, & 1454

and by the end of the season I anticipate that nearly half the crop in these last plots will have been destroyed.

Both these last cases are diseases caused by soil parasites. It is arguable that the manure has acted rather by affecting the growth of the parasite than by altering the true resistance of the plant. This aspect of the question is now under investigation, and in any case it cannot be called in to account for most of the following, as they refer to parasites of the above-ground parts of the plant.

At Rothamsted, where permanent manurial experiments have been continued during many years, the high nitrogen plots are the most susceptible to several diseases including rusts and *Epichloe typhina.* The potash-starved plots are, however, reported to be the first to succumb to wheat and mangold rust in bad years of disease. The normally-manured plots suffer much less from these diseases.[2]

At Woburn also the nitrogen plots in the manurial series (which has been running for over 30 years) are the most rusted.[3]

---

[1] See page 65 of this Number.

[2] Russell, E. J. "Fertilisers and Manures," 1915: "Soil conditions and plant growth," 1912: "Soils and Manures," 1915.

[3] Spinks, G. T. "Factors affecting susceptibility to disease in plants." *Journ. Agric. Science*, V.

In France it has been found that a heavy dressing of nitrate of soda can, by itself, bring on an attack of grey rot in grapes, the parasite (*Botrytis cinerea*) being always present to some extent in most vineyards.[1]

Copious applications of farmyard manure are well known to predispose potatoes to blight,[2] and gooseberry mildew has been observed in England to be worst on the sappy growth induced by similar treatment.[3]

In tea manurial trials in India, my colleague Mr. Hutchinson informs me, the amount of the die-back disease of the twigs (probably caused by a *Glœosporium*) varied directly with the dose of nitrate of soda.

Examples from agricultural practice of this effect of nitrogenous manuring could be multiplied, and the phenomenon has been confined under the more rigorous conditions of water culture. It has been found, for instance, that both rust and mildew of cereals attack most severely the plants grown in nutrient solutions containing double or quadruple the quantity of nitrogen required for normal growth.[4]

Phosphates and potash both are reputed to have an influence in increasing disease resistance. The action is best established for potash, both by practical experience and scientific experiments. The evidence of the potash-starved plots at Rothamsted has already been referred to. So also in water cultures the plants grown in solutions in which the normal amount of potash was doubled or quadrupled, showed a reduction in the amount of rust and mildew in cereals, but the effect was not enough to counteract the injurious influence of an excess of nitrogen.[5] It is a common practice of growers of plants under glass, such as tomatoes in England,

[1] Delacroix, G. "Observations et recherches au sujet de la 'pourriture grise,' &c." *Bul. Mensuel de Renseign. Agricoles.*, April, 1905. "Maladies non-parasitaires des plantes cultivées," 1908, p. 355.

[2] McAlpine, D. "Potato diseases in Australia," 1911, p. 27.

[3] Salmon, E. S. "American gooseberry mildew," *Journ. Board Agric.*, XX, 1913 1914. Brooks, F. T., Petherbridge, F. R., & Spinks, G. T. "Experiments on American gooseberry mildew in Cambridgeshire," *ib.*, XXII, 1915-16.

[4] Spinks. *l. c.*

[5] *ib.*

to check the ravages of various parasites by potash manuring. Kainit has also obtained a reputation in several cases as a preventive of disease and is believed to act through its potash content.

Phosphatic manuring has been used with success in the control of root rot of tobacco and ginseng, caused by *Thielaria basicola*. But the fungus is a soil dweller and it is possible that the manure acts directly on it and does not affect the resistance of the host plants.[1] Phosphates also increase the resistance of potatoes to blight and in a good many other cases they seem to be beneficial. Two instances of the opposite effect have, however, been examined. In the disease caused by *Sclerotinia Libertiana*, a fungus which attacks a number of garden plants, superphosphate has been found to reduce resistance under certain conditions.[2] This fungus requires an acid medium for its parasitic growth and appears to have the power of secreting acid. In lime soils the acid tends to be neutralized and plants grown in such soils resist the disease. Heavy manuring with superphosphate restores the acidity of the tissues and enables the fungus to thrive. In the lettuce mildew, *Bremia Lactuca*, phosphates have also been found to reduce the resistance of plants grown in water culture.[3]

Thus each of the three most important plant foods, nitrogen, potassium, and phosphorus, is capable of influencing the resistance of plants to disease, and this influence is undoubtedly physiological in its nature. How they act is not known. The few indications we have of the effect of various fertilizers on the cell contents show that there is here a most promising field for investigation.

For instance, it has been established that heavy doses of nitrogen have an effect, in some cases, not only in causing the production of

[1] Whetzel, H. H, and others. "Ginseng diseases and their control." *U. S. Dept. of Agric., Farmers' Bul.* 736, 1916.

[2] Laurent, E. "Recherches expérimentales sur les maladies des plantes." *Ann. Inst. Pasteur*, XIII, 1899: "Recherches de biologie expérimentale appliquée à l'agriculture," 1, 1901—3.

[3] Marchal, E. "Recherches de biologie expérimentale appliquée à l'agriculture," I, 1901—3.

thin-walled cells, rich in sap, but that the composition of the latter is altered by increasing the quantity of reducing sugars and diminishing the quantity of organic acid.[1] In this connection it is interesting to note that lemon-growers in Italy find that nitrogenous manures give a less acid fruit, and as this is undesirable, and also the bushes become more liable to gummosis and the fruit to rotting, they counteract the effect by applying phosphates.[2]

In the same way, the action of phosphates, particularly of superphosphate, on the cell contents is believed to result in an increase in the acid reaction of the juice, and this may be the explanation of the observed effects of phosphatic manuring referred to above.[3]

It has already been pointed out that organic acids are believed to play a considerable part in the immunity of plants to disease. But it must be admitted that the analytical basis for this belief is as yet scanty. It is obviously necessary to examine more closely the effect of various fertilizers on the cell contents. If it could be shown that substances such as the rapidly assimilable nitrates, that are known to predispose to disease when applied in excess, act always in the same manner on some single part of the cell contents, such as the acids, then a considerable step in advance would have been taken. Enzymic activity, on which fungi chiefly depend for reaching and making available their food, is often closely dependent on small differences in reaction. No one who examines the evidence can doubt that the fuller investigation of the influence of external conditions, soils, manures, climate, and the like, on the cell contents and particularly on the organic acids, is destined to shed much light on the obscure problem of physiological immunity. We have still a long way to go before we can equal for plants the knowledge gained by the physiologists and pathologists of the causes of human and animal immunity. But there is no reason to suppose that the difficulties are greater than those that have been

[1] Comes. *l.c.* p. 442.
[2] *ib.* p. 450.
[3] Delacroix, G. "Maladies non-parasitaires des plantes cultivées," 1908, p. 369.

so brilliantly surmounted by the latter investigators. I have indicated the direction in which I believe that progress lies, and one of my main objects in reading this paper is to appeal to agricultural chemists to give some attention to a field for investigation which has not been sufficiently explored, in order that they may help in the solution of one of the most important problems in agriculture.

Photo by J. W. Oliver

Teak plantation in Burma, three years old, formed by sowing teak seed in combination with the cultivation of a catch-crop.

THE ECONOMIC ASPECT OF INDIAN SILVICULTURE.

BY

EDWARD MARSDEN,

Silviculturist, Forest Research Institute, Dehra Dun.

A CRITICISM often brought against the Forest Department in India is that it has not introduced modern methods of felling and extracting timber from the forests. The critic generally implies that we ought to follow the American plan of laying railways with portable extensions and of establishing a sawmill in the forest to cut up everything within reach. The construction of mechanical works of export depends on the trees growing close together and not scattered, and on the majority of the trees being saleable. It requires no great effort to understand that if 50,000 trees, instead of being dispersed over 50,000 acres, can be concentrated within 1,000 acres, the cost of export works for their exploitation will be greatly reduced, and the profits of the enterprise will be vastly enhanced. But in India the great majority of valuable trees grow scattered singly over large tracts, as in the tropical forests of Burma, Assam, and Madras ; and even in the sal forests of Northern India, or in the deodar and pine forests of the Himalayas where the trees are all the same species, the stems of marketable size are generally distributed widely amongst smaller trees of all ages. Nevertheless concentrated exploitation is the way to make the greatest profit out of any forest, and the only way to make any profit out of the less accessible forests. Ideal conditions are exhibited in a forest consisting entirely of closely grown trees of valuable species, arranged in a succession of more or less even-aged crops. This aim has been

fulfilled in the teak plantations at Nilambur in Madras, where this year the fellings over 21 acres have realized Rs. 1,54,500 net, or an average of Rs. 7,370 per acre. The best acre fetched Rs. 13,450 net, including cost of extraction; this plantation was 72 years old.

The silvicultural problem confronting every Indian forest officer is how to replace the existing forest containing trees of all sizes and often of great variety by even-aged blocks fully stocked with valuable species. There is only one way to do this: by taking in hand a tract of forest and methodically concentrating upon the clearance of all old trees within the selected tract, substituting for them within as short a time as possible a crop of vigorous young seedlings. The problem always resolves itself into a question of regeneration: how most cheaply and effectively to raise the young crop. Undoubtedly the cheapest is natural regeneration; in a virgin forest when an old tree dies and falls, or when a single mature stem is felled, its place is invariably taken by others which spring from seed cast by the surrounding trees. But the process takes time; though absolutely certain, Nature's methods are very slow. Moreover, the selection of single trees scattered throughout the tract precludes the possibility of concentrated exploitation. The trouble is that the larger the number of trees felled and the shorter the time-limit set to the period of regeneration, the greater is the risk of failing to restock the tract fully with vigorous seedlings. Yet, unless the time-limit is fairly short, an even-aged crop will not be produced, and the resulting stock may consist of trees as irregular in size as those of the forest which it is replacing. Natural regeneration is thus always a compromise between the demand of man for an even-aged, regular forest of considerable extent, and the natural character of trees to reproduce themselves over comparatively small areas and to form an irregular forest.

When dealing with trees whose silvicultural character had not been studied, in order to ensure the replacement of those felled, our predecessors had to proceed over small areas and to select either single stems or small groups for felling. But when some knowledge had been acquired of the demands made by the young seedling

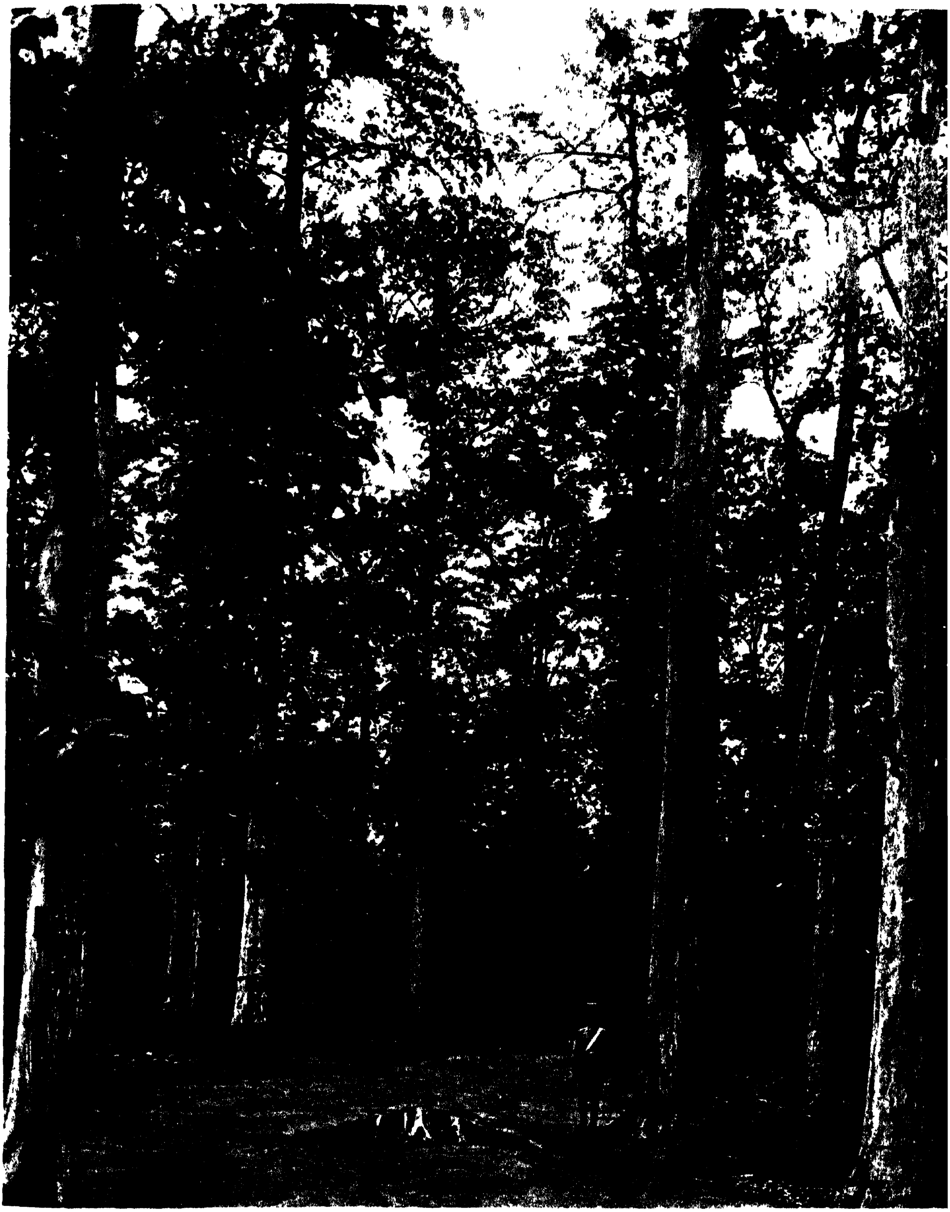


Photo by R. S. Troup

Teak plantation at Nilambur, Madras, age 65 years, nearly mature.

upon moisture, shelter, light, and soil, the length of the regeneration period could be reduced, and the area of the tract taken in hand increased. With full knowledge of such demands, a time-limit of 10 to 20 years can reasonably be set for the complete natural regeneration of a tract of forest in a temperate climate. But even so, the young crop will vary in age from 1 to 20 years, and this degree of irregularity must be admitted in the compromise between man's demands and Nature's methods.

It is clear, I hope, that the cheapest way of replacing the existing irregular woodlands by even-aged blocks of forest, namely, natural regeneration, depends for its success primarily upon a knowledge of the young seedling's requirements. This is the point upon which silvicultural research should concentrate.

Proceeding from the dry, temperate climate of the Western Himalayas to the damp, temperate climate of the Eastern Himalayas and to the damp, hot climate of Assam and Burma, the variety of species increases greatly, and the difficulties of natural regeneration accumulate. Any break in the heavy cover of the forest caused by the death or the fall of a tree is filled at once with weeds, climbers, or softwoods. These forests may contain 200 or 300 different kinds of trees to the square mile, and there is generally present a lower storey of bamboos 60 to 100 ft. high. Growth is rapid, and communications bad. It is certain that felling trees here will not mean the destruction of the forest; something will come up, and very soon too. But nearly always what comes up is not what man wants. Supposing we wanted to obtain natural regeneration of teak in Burma: there are about 25 big trees of different sorts to the acre, and of these perhaps three are teak; under such conditions how is it possible to modify the shelter so as to favour the natural reproduction of teak to the exclusion of all the other species? And we are faced with the same difficulty whatever particular tree we may select. The only practical method in such tropical damp countries is to fell every tree and to restock by sowing or planting the kind we want.

In this connection, I should like to invite attention to the method of introducing trees by sowing the tree-seeds in combination

with the cultivation of catch-crops. When the crops are reaped, the little trees remain to grow up into forest. By this means the seedling trees receive at little or no cost the advantages of weeding, tending, and soil-loosening. Results have been so encouraging that this method of forming plantations deserves the utmost attention wherever local conditions render its introduction practically possible.

We know that the unrestricted extension of plantations formed of a single species is dangerous owing to the risk of inducing a plague of insects or fungi. The policy then should be to form either mixed plantations or pure plantations of limited area. No two species make the same demands on light, moisture, shelter, or soil ; almost always one kind grows quicker than another, and an irregular wood with widely-spaced, branchy trees results. The two points in timber for which the market is ready to pay a big price are length and freedom from defects. Branchy trees connote knots in the timber. Hence it is better to form pure plantations of moderate size rather than mixed plantations of larger area. The aim should be to establish pure plantations of 50 to 300 acres in extent, arranged so that adjoining plantations differ from each other in species and age.

The obvious step is to raise valuable trees like teak and rosewood. But it seems to me that further consideration is wanted. These hardwoods take 80 or 100 years to mature ; throughout this long period not only are they open to danger from fire, insects, and fungi, but the return on the money invested in their production is deferred, and the plantations not yet mature represent a very large working capital. A timber-crop which could be realized at an earlier age, say 25 years, would be worth consideration even if the value of the wood were a good deal less. Assuming a rate of 4 per cent. compound interest, the present value of 1,000 cubic feet of hardwood, worth Rs. 5 per cubic foot to be realized after 100 years and thereafter every 100 years, is Rs. 101. The present value of 1,000 cubic feet of softwood, worth annas 3 per cubic foot to be realized after 25 years and thereafter every 25 years, is Rs. 112.

The specially favourable condition for growth which these tropical forests enjoy is the hot, damp climate. To utilize fully

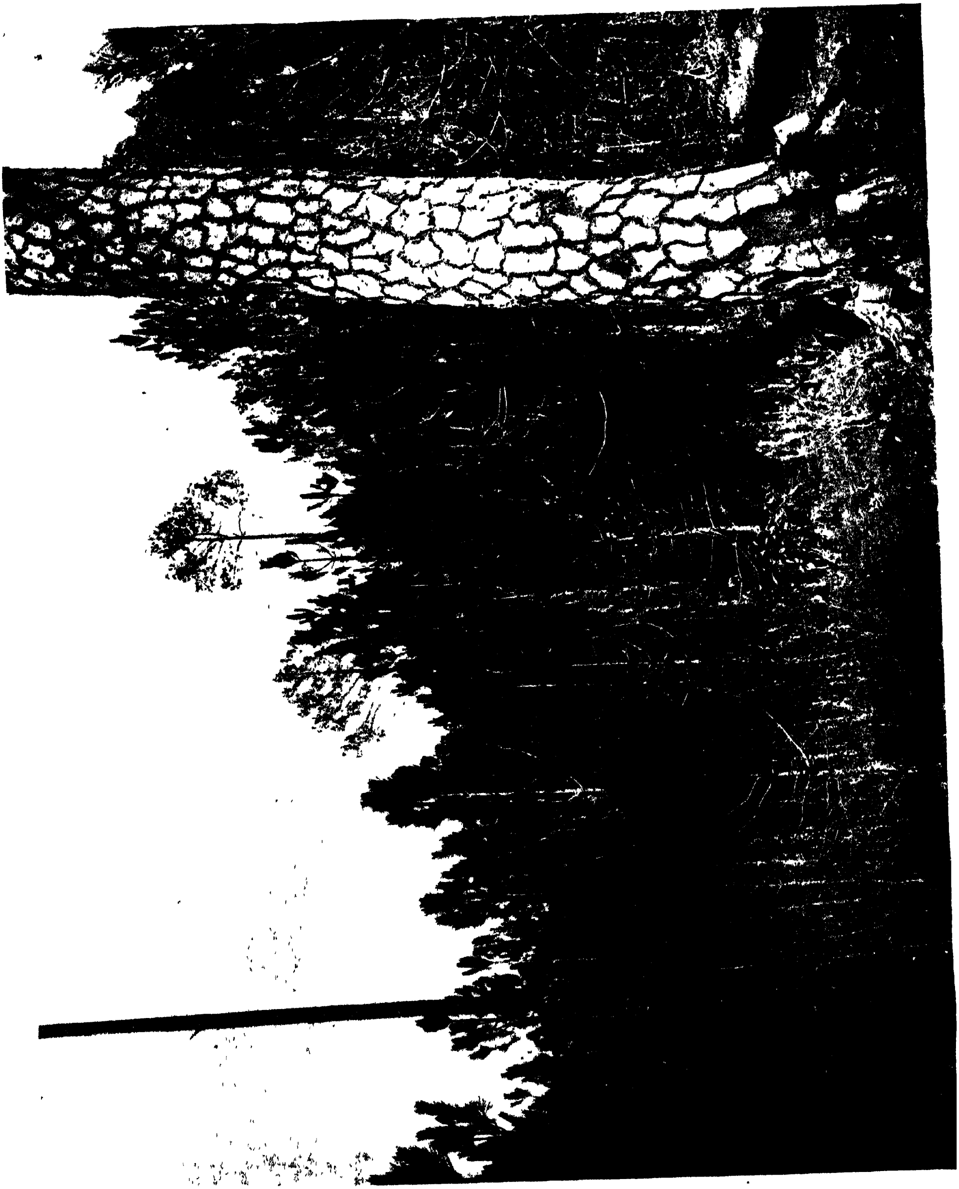
PLATE III.

Fig. 1. Chir pine forest, closed to grazing, showing natural regeneration.

Photo by R. S. Troup.

Fig. 2. Chir pine forest, open to grazing, showing complete absence of natural seedlings

PLATE IV.



processes necessary for the plant growth. In 1901 Kastle and Loevenhart[1] advanced the view that the oxidase is not a true soluble ferment but an organic peroxide. The part played by oxidases in the coloration of tea and coffee has been investigated by Aso[2] and Gorter[3] respectively ; the influence of oxidase on the ripening of fruits and roots by Brooks,[4] Thatcher[5] and Appleman,[6] the relation of respiration to oxidase by Bach[7] and Reid,[8] of pigment and colour production by Bailey,[9] Keeble and Armstrong[10] and others. Quite recently Bunzel and Reid have studied a number of important problems in connection with the subject.

II. Experimental.

1. *Detection of oxidase in the sugarcane and its action on various reagents.*

All the oxidases have this property in common that they blue tincture guaiacum, either with or without any hydrogen peroxide. Hence blueing of guaiacum tincture has come to be regarded as a test for the presence of oxidases. We find that the sections of the cane from the node or the internode portion, the juice from the leaves, the stem and the roots, all respond to this test. It was further found that the positive reactions are obtained with benzidine, hydroquinone, L. napthol, pyrogallol, salicylaldehyde, toluidine, paraphenylenediamine, phenol-phthalin, and indophenole reagents ; while the reaction is negative with carvacrol, eugenol, tyrosine, and vanillin. The positive reactions develop better and comparatively sooner in solutions where hydrogen peroxide is present than where this is absent. Thus tyrosinase is found to be absent from the cane, while the presence is shown of laccases and aldehydase.

---

[1] *Amer Chem Jour* , 1901, 26, pp 539—566
[2] *Bull. Coll. Agric Tokyo. Imp Uni* , 1901, IV, No 4, pp 255—259.
[3] *Annalen*, 1908, 359, pp 217—244.
[4] *Journ. Amer. Chem. Soc.*, 1912, XXXIV, p. 67.
[5] *Journ. Agric. Res* , V, No. 3
[6] *Bot Gaz.*, LII, p 306, 1911.
[7] *Arch Sci. Phys. Nat.*, 1913, 35, pp. 240—262
[8] *Journ. Bio. Chem* , 1915, 22, pp. 99—111.
[9] *Bot. Gaz.*, L, 1910.
[10] *Proc. Roy. Soc.*, 1912, B, 85, pp. 214—218, and *Journ. Genetics*, 1912, 2, pp. 277—311

2. *Preparation of the oxidase extract.*

The leaves, stems, or roots from whatsoever source it was desired to obtain the extract were first sliced finely in a hand-slicing machine and then crushed in an iron pestle and mortar, with the help of well-washed sterilized sand. Water is added during crushing if required. The pulp so obtained is taken up with water and kept soaked under it for about six hours, when it is pressed out through a thick cotton cloth. The extract so obtained is filtered either over Buchner or through Birkfield porcelain candle, when a strong oxidase extract is obtained, which can keep for a number of months if a little chloroform be added as a preservative or preventive of decay by bacteria.

3. *The phenomenon of browning and the chromogen of the cane.*

It has been observed that when sections of sugarcane are out and left exposed to the atmospheric oxygen, they gradually begin to brown. This browning of the freshly cut surface of a number of plants and fruits has been observed by a number of workers and is universally ascribed to the action of oxidases. The cane extract also just after filtration through Buchner begins to brown rapidly. The browning so noticed seems to be due to the oxidation of the chromogen of the cane by atmospheric oxygen through the agency of the oxidases. The chromogen concerned seems to be some substance allied to tannins, for it can be removed by shaking the extract with hide powder and filtering. The juice so clarified again begins to brown if some drops of a dilute solution of tannic or pyrogallic acid are added. Tannic acid present in the juice does not seem to belong to the gallotanic acid group, for when the extract is treated with lime-water we get a red precipitate characteristic of the oak tannins instead of the blue precipitate with gallotanic acid. The solutions of gallic, tannic, and pyrogallic acids were prepared and simultaneously with cane extract were treated with lime-water, ferric chloride, potassium cyanide, lead nitrate, gelatine, and sulphuric acid. The reactions obtained with cane juice while

differing entirely from those with gallic acid and tannic acid resembled those with pyrogallic acid.

Miss Wheldale[1] has published an interesting paper on the subject of browning and chromogen in plants which give direct guaiacum reaction without the addition of hydrogen peroxide. According to her, the browning of tissues on mechanical injury or exposure to chloroform vapour and the power of blueing guaiacum directly are both associated with the presence in the plant of pyrocatechin. All attempts to extract pyrocatechin from cane extract with the help of alcohol and ether entirely failed in the hands of the author. The cane extract also failed to give any blue with guaiacum, which had been previously deprived of its peroxide by treatment with animal charcoal, even on the addition of alkaline pyrocatechin which had been allowed to brown on exposure to atmosphere ; but the addition of a drop of a very weak solution of hydrogen peroxide (0·03 per cent.) brings the blue at once. Potato which blues ordinary guaiacum directly also behaves similarly as cane juice. These reactions with potato show that the substance responsible for giving blue coloration with charcoal-treated guaiacum is not pyrocatechin, as suggested by Miss Wheldale, but some peroxide as Moore and Whitley think; and contrary to the view of these latter authors it is not present in potato juice naturally as such but must be added from outside, either in the natural form with guaiacum not treated with charcoal or as free hydrogen peroxide when charcoal-treated guaiacum is used.

In order to further test Miss Wheldale's pyrocatechin theory we took a number of plants* of the orders mentioned by her and which ought to give direct guaiacum reaction. The extracts from

---

[1] *Proc. Roy. Soc.*, B, 84, p. 121, 1911.

* *Plants*		*N. Orders*
1. Pudina (*Mentha Viridis* Linn.).	..	Labiatæ.
2. The rose.	..	Rosaceæ.
3. Aru (*Prunus persica* Benth , H K.)	..	Do.
4. Lasura (*Cordia myxa* Linn)	..	Boraginaceæ.
5. Sann-hemp (*Crotalaria juncea* Linn.)	..	Leguminosæ.
6. Indigo (*Indigofera tinctoria* Forsk)	..	Do
7. Radish (*Raphanus sativus* Linn.)	..	Cruciferæ.
8. *Bryophylium Calcinum* Salisb.	..	Crassulaceæ.

none of these plants, however, gave positive reaction with carbon-treated guaiacum on the addition of brown pyrocatechin solution, whereas with untreated guaiacum or on the addition of hydrogen peroxide when treated guaiacum was used, the blue colour was obtained at once, the intensity of the colour depending upon the more or less amount of hydrogen peroxide. From the above experiments and discussion it is apparent that direct guaiacum reaction depends more upon the presence of peroxide than upon that of pyrocatechin.

All the above plants were tested for the presence of pyrocatechin. The crushed mass was treated with alcohol, chloroform, and ether, and the extract so obtained evaporated to dryness on the water bath. It was taken up with water and tested with ferric chloride and sodium carbonate solution. Positive reactions were obtained with Pudina, Rose, and Aru ; doubtful with Radish, Lasura, and *Bryophylium*, and negative with Hemp and Indigo.

4. *The action of preservatives.*

The cane extract on keeping deteriorates and soon moulds begin to be formed, specially when in contact with air. In order to prevent this decay some preservative must be added. For the purpose, the action of chloroform, toluene, and ether was studied. The leaves of the cane were crushed with these preservatives added from the very beginning and the extract obtained as usual. The action of these extracts was studied on a number of oxidants. The same colour reactions are obtained with all the three extracts, only they are somewhat more speedily obtained with chloroform than with ether.

The effect of these reagents was studied in another way. To 100 c.c. of the leaf extract obtained without any other previous treatment with any preservative, 5 c.c. each of chloroform, toluene, and ether were added. The time taken for the appearance of guaiacum blue and the blue due to the liberation of iodine from hydroiodic acid under the influence of oxidase was taken as a measure of oxidase activity. It varies directly with the quantity and quality of the active oxidase present. Again, the oxidase

extract is acidic from the very beginning and the amount of acid present increases as the extract deteriorates ; so any increase in the amount of acid is a sure sign of decay. The results obtained are as under :—

1. *Acidity (in terms of NaOH N/50 required to neutralize 5 c.c. of juice.) :—*

	Toluene	Ether	Chloroform
After 24 hours.	2 2	1·8	0 8
,, 48 hours	2·5	2·3	0·8

2. *Potassium iodide starch reaction* (5 c.c. juice ; 2 c.c. KI aq. 10 per cent. ; 2 c.c. ½ per cent. starch paste ; 10 c.c. water ; and three drops 20 per cent. sulphuric acid) :–

Time taken for the blue colour to appear.

	Toluene	Ether	Chloroform
After 24 hours	Nil during 10 minutes	Nil during 10 minutes	35 seconds
,, 48 ,,	Do.	Do.	45 seconds

3. *Tincture guaiacum.* (Both carbon-treated and untreated.) (5 c.c. juice—0·2 c.c. guaiacum.)

	Toluene	Ether	Chloroform
After 24 hours		—	Instantaneous
,. 48 ,,	—	-	Do

It is found that if we increase the quantity of the guaiacum used positive results are obtained even with toluene and ether extracts, the former taking 1·6 c.c. and the latter 0·8 c.c. of fresh guaiacum.

Thus it becomes quite clear that the chloroform exerts by far the best preserving influence.

Working on the oxidases of the tea leaf Mann[1] found that the oxidase is destroyed if kept in contact with chloroform vapour. Our experience, however, is quite the contrary. An extract freshly prepared was divided into two portions in stoppered flasks, one of

[1] Ferment of the tea leaf " Indian Tea Association, 1901.

these was kept with chloroform and the other without any preservative. It was found that the extract without any preservative begins to ferment and gradually the colour changes from deep brown to pale yellow with the formation of a whitish brown precipitate. After three months it was found that the pale yellow extract has lost considerably its original power of blueing guaiacum, and after seven months gave no blue even on the addition of hydrogen peroxide. The one with chloroform retained its activity even after 14 months, although the blue obtained was tinged with green. On the addition of hydrogen peroxide it changes to deep blue.

5. *Effect of medium on the action of the oxidases.*

The plant extract as prepared in the usual manner after passing through Birkfield filter was slightly acidic. A portion of it was rendered alkaline to litmus by the addition of some drops of ammonia, and the other corresponding sample was kept in its original acidic condition. On applying the oxidase reactions it was found that better colour reactions are obtained in alkaline media than in acidic.

When the acid is added to the extract from outside, the guaiacum blue takes longer in coming, the time taken depending directly on the amount of acid present. Thus it was found that in one sample of extract prepared about one month previously, a concentration of 2·08 parts per 10,000 was sufficient to stop the reaction ; while in another freshly prepared sample 1·04 parts per 10,000 was quite sufficient to bring about this result.

The effect of the addition of dilute sodium hydroxide solutions was also tried. The action of alkali is to change the blue colour to green. The results may be thus summarized. The effect of increasing the amount of alkali, up to a certain limit, is to retard the appearance of blue. However, when the blue gives place partially to green, the time taken by the reaction gets less and less so that beyond a certain limit, the green comes instantaneously. On further addition of alkali, however, a concentration is reached when green also disappears giving place to a dirty yellow, the colour due to the action of the caustic soda on tincture guaiacum itself.

When the nature of the medium has such a strong influence, it is just possible that the difference in reactions observed in different samples compared may be due to the differences in the alkalinity or acidity of the cell sap, rather than to any difference in the quantity of the oxidase present. Pavy and Bywaters[1] have demonstrated the influence of environment in the case of aqueous extracts of yeasts. They found that the inverting power of yeast juice is greatly increased by the addition of acetic acid. The activity given by acid addition is susceptible of removal by a basic substance. The authors give a number of cases where the enzyme action in different samples is accelerated or inhibited by changing the reaction of the media in one direction or the other, and conclude that the activity is determined by the state of the environment. With the metabolic changes into which enzyme action enters sequences occur from the demand existing. Inactivity passes into activity as the demand arises for the changes, and circumstances reasonably point to the environment constituting the medium through which the issue is worked.

It has been found by a number of workers[2] that the "oxidases" work best in alkaline medium. Our study of the cane oxidase, however, does not bear out the conclusion. We have shown that the presence of acid to an extent to which it is present in the plant is not harmful to cane oxidase. Besset and Thomson[3] found that the oxidase in some fruits, such as apples, pears, and walnuts, is active only in slightly acid solution.

Even granting that the oxidase reactions are accelerated in alkaline medium, it cannot be presumed that the alkaline medium is one best suited for plant growth. In the laboratory of the plant there are taking place a number of other reactions, enzymic or otherwise, which may work best in acid medium. And we know as a matter of fact that some of these do require an acid medium. The

---

[1] "On the governing influence of environment on enzymic action." *Journ. Phys*, 1910, XLI, p. 14.

[2] Rose. "Oxidation in healthy and diseased apple bark." *Bot. Gaz.*, 1915, LX, p. 55; Jules Wolff. "Existing action of alkali specially ammonia on peroxydase." *Comp. rend.*, 1912, 135, p. 484.

[3] *Journ. Amer. Chem. Soc.*, 1911, XXXIII, p. 416.

plant has to look to the requirements of these also and cannot "help" the oxidases at the expense of the other reactions. Again it may not be in the interest of the plant growth that the oxidases may have a reaction velocity greater than what they have in originally acid medium. The slow rate at which the oxidases work in acid medium may be best suited to the assimilation of the products of oxidation, which otherwise being formed too rapidly will accumulate and may have a toxic effect or otherwise retard the growth of the plant.

6. *Strength of oxidase in different portions of the cane.*

The term strength here should be taken to depend directly upon the amount of substrate oxidized, *i.e.*, to the intensity of the reaction and may be due to the quantity or activity of the oxidase or may be the joint effect of both these. Tincture guaiacum and pyrogallol were used for the purpose. The results obtained are summarized below :—

A. The cane stem was divided into two portions and their activity compared. It was found that the upper gives a stronger oxidase reaction than the lower.

B. *Rind and pith.*

1. The cane was stripped of its rind, and the rind and pith so obtained were crushed separately and their activity compared. It was found that the rind was far stronger than the pith.
2. Rind from different portions of the cane. Rind from the upper portion of the cane was stronger than from the lower, and that from the lower stronger than from upper.
3. Pith from different portions of the cane. Pith from middle portion of the cane was stronger than from upper, and that from the upper stronger than from lower.

C. *Nodes and internodes.*

Although the weight of the nodes as compared to that of the internodes in the cane is much less, still they contain about 25 per

cent. more of the active oxidase than the internodes. Again, both the nodes and the internodes from the upper regions of the cane are stronger than from the middle and from the middle, stronger than from the lower.

D. *Leaf and stem.*

The oxidase in the open flat portion of the leaf is stronger than in the sheath leaf, *i.e.*, curled up portion of the leaf, and stronger in this latter than in the stem itself.

The above results seem to be quite in economy with the requirements of the plant. Those portions which are physiologically more active contain more of the active oxidase than the others; for instance, the leaf and the adjoining greenish portion of the cane are richer in oxidase than the stem, and we know that leaf is the seat of all photosynthetic processes. Again, nodes which are in direct connection with the leaves are stronger than the internodes. The rind is stronger than the pith. This may be explained from the point of view of the protection of the plant against mechanical injury or the attack of parasites such as *Trichosphæria sacchari* and other similar fungoid pests. When injured the oxidase comes in contact with the colourless precursor of pigment and oxidizes it into a substance which has toxic properties. Again, we know that the stem of the cane is the storage organ of the plant to store the sugar manufactured in the leaf, and the lower portion of it near the bottom is much richer in sucrose than the upper. Hence whenever the plant may have to fall upon its reserve food for energy supply it will have to take it from the sugar stored, which however to be of any use for plant growth must at first be oxidized. Thus it is quite in keeping that the lower portion of the cane may be stronger than the upper in oxidase activity, specially so with the ripe canes where the lowest portion of the stem contains more sucrose.

7. *Effect of boiling the oxidase extract.*

One of the chief properties of the enzymes is their sensitiveness towards heat. On heating their solutions to the boiling point, they cease to be active and the activity does not return on cooling or by any other subsequent treatment. It was found by us that the

activity of the oxidase extract, though apparently destroyed on boiling, is in fact only suspended temporarily. It regenerates itself on cooling and keeping to an almost the same extent as before. It is immaterial whether the juice used has been clarified or not. The regeneration is more complete with clarified than with unclarified, however. This destruction of the oxidase bears an inverse proportion to its amount present in the solution. In contradiction to the observations of Bach and Chodat[1] the activity returns even on boiling the juice twice. We cannot confirm Doney-Henault's[2] observation that the oxidase is destroyed on boiling owing to the production of acid during the process. We could not detect this increase in the amount of acid on boiling.

Mechanism of the process of oxidase regeneration from their boiled solutions. We have observed that *immediately* after boiling the plant extract, its oxidase activity seems to be almost destroyed, but returns on keeping the boiled extract. Up to a certain hour the regeneration is proportional to the time of keeping, when it reaches the maximum value, and further keeping will bring in no more revival of the activity. The extract loses some of its activity permanently, however small may be this loss. This phenomenon can be explained by assuming the "oxidase" as a system rather than a single compact molecule; the different components in the system being connected with each other by bonds or affinities which are liable to break on the application of heat. When an oxidase solution is boiled, most of these "oxidase molecules" get separated into different components. A certain percentage of these components undergo further constitutional changes at the high temperature and are thus permanently thrown out of the oxidase system. But having been thus destroyed they may act as a protecting shell or screen to the remaining disrupted components up to a certain extent. These disrupted molecules are thus saved from a permanent destruction and on keeping gradually combine again to regenerate the complete oxidase system. There may be still a portion—

[1] *Ber. d. deut. Chem. Gesell.*, 1903, 36, pp. 600—605.
[2] *Bull. Acad. Roy. Belg.*, 1909, pp. 342—409.

although a very small percentage—of the total oxidase molecules, which has escaped any disruption altogether and is quite intact. This represents the portion of the oxidase molecules which give the positive blue reaction with guaiacum immediately after cooling. This residual power of blueing guaiacum, although quite small, is quite distinct in many samples.

In view of the facts stated above, we must hesitate to classify the oxidase as an enzyme. If it is enzymic in character, it is the only example where an enzyme has not been destroyed on boiling its solution even twice or when it has again regenerated itself on keeping, and our conception of an enzyme must undergo a radical change.

8. *Action of reducing agents on the oxidase.*

Moore and Whitley found that the oxidases are extremely susceptible to the action of reducing agents, so much that they are completely and irrecoverably destroyed. We can very well understand this sensitiveness if the oxidases are enzymic in character. However, we are able to confirm these authors only partly. A long and systematic study of the action of hydrogen sulphide upon oxidase under widely differing conditions was undertaken. The extract was tested boiled and unboiled ; clarified and unclarified ; clarified boiled and unclarified boiled ; and in the presence and absence of chloroform as any preservative. The regeneration of activity was studied with guaiacum tincture and starch potassium iodide reagent. The results of our experiments may be briefly summarized thus. The effect of sulphuretted hydrogen is merely to inhibit the activity temporarily and never to destroy it permanently. In course of time the oxidases are able to recover from the toxic effect of H_2S, much sooner when chloroform is present and exercising its preservative action. Even those samples which had been subjected to the double treatment of boiling and the action of hydrogen sulphide simultaneously, are able to recover their activity if kept sufficiently long. On clarification the oxidase extract does not immediately give positive reaction with starch and potassium iodide reagent. Even this clarified juice when boiled and

treated with H_2S, recovers its activity if kept sufficiently long. It cannot be said with any amount of certainty whether it is the same oxidase which was originally present in the extract that recovers from the effect of these drastic treatments, or this original oxidase being destroyed by combining with H_2S or removed by clarification a fresh quantity is regenerated from some precursor of it which is present in the extract and is either not affected at all or very slightly affected by these different treatments. As we had an occasion to refer before, the complete and permanent destruction observed by Moore and Whitley is only apparent. Perhaps these authors tested their extracts *immediately* and *only* immediately after adding H_2S. At least we find no reference in their work if they did otherwise.

9. *Acidity of the cell sap and its function and significance.*

It has been already stated that the cane extract in the absence of chloroform deteriorates, and its activity increases on keeping. Thus a particular sample of the extract showed during 40 hours an increase in acidity about three times the original figure. This was accompanied with the disappearance of the usual oxidase reactions. We find that in some cases the removal of the acid generated on keeping the oxidase extract is sufficient to bring back the oxidase reactions, but in other cases the addition of hydrogen peroxide is necessary. This was found to be the case in the particular sample referred to above.

We have seen that the oxidases are extremely sensitive to the reactions of the cell sap. This sensitiveness is much more marked in the case of the enzymes; while in the case of any one particular enzyme a slight increase of acid may be favourable for its action, this same slight increase may become prejudicial to the other enzymes. The cell, if it were to have the power of controlling the amount of acid present in the sap, will possess a very effective mode of allowing only a particular kind of reaction or reactions to proceed at a certain time, while at some other time keeping these in obeyance and allowing other kind of reactions to go on. That it

possesses this power of varying the acid concentration at different times of the day is shown by a couple of experiments performed by us. Two kinds of cane were selected, the longer fully grown up ones and the smaller ones not fully developed. Acidity on 100 grs. of wet and dry leaves in terms of c.c. of N/10 NaOH was found to be as follows :—

		Wet leaves	Sun-dried leaves
Fully developed canes	Morning	27·82	60·60
	Afternoon	16·72	40·10
Undeveloped canes	Morning	34·24	114·91
	Afternoon	8·93	21·41

Thus we find that in both the cases the acidity falls with the sun. This would mean that the oxidation processes are suspended in the morning, but have their full swing when the sun is highest, *i.e.*, they run parallel with the other photosynthetic processes.

In this connection mention may be made of the work of Petit.[1] It is known that barley contains an enzyme which saccharifies starch paste but does not liquefy it, the liquefying action being only developed on germination. The author, however, found that the same effect is produced by simply varying the acidity. Thus we see that a simple variation of the acidity contents of the reacting media conferred on barley diastase the power of liquefying starch paste.

10. *Starch potassium iodide test for oxidases and the presence of nitrites in the cell sap.*

Aso and more recently Wolff and de-Stoecklin have questioned the validity of starch potassium iodide reaction as a true test for the oxidases. They attribute this reaction to the presence of nitrous acid occurring in the plant extract.

Greiss's reaction is the only one best suited to test the presence of nitrous acid when it occurs in small amounts. This reaction when applied to the cane extract gave a coloration which was rather pinkish yellow than pink. It is doubtful whether on the basis of

[1] *Compt. rend.*, 1904, 138, pp. 1003-1004.

this reaction we are justified in assuming the presence of nitrites in our plant extract. However, taking for granted that this colour is due to nitrites, the next point is to decide whether this amount of the nitrite is sufficient to give the starch potassium iodide reaction. This can be done in two ways. The amount of nitrite in the extract may be estimated in terms of a known nitrite such as sodium nitrite ; and then a solution may be prepared that would contain as much sodium nitrite as has been found to be present in the extract. Now starch potassium iodide reaction may be applied to both of these solutions. If the reaction is carried to the same extent in both the cases then it would mean that the reaction is not a distinctive test for oxidases. The other method to test the point is to see whether the oxidase powder obtained by precipitation with alcohol from leaf extract gives the Greiss's test, and if so whether the starch potassium iodide reaction comes to the same extent as with a solution containing the corresponding amount of nitrite. The experiments performed as outlined above show distinctively that the amount of nitrite detected by Greiss's test is not sufficient to give the starch potassium iodide reaction. Hence we are justified in assuming that the greater part, if not the whole, of the reaction is due to the substance or a system of substances which we call "oxidases."

11. *The nature of oxidases : Are they enzymes ?*

Our conception of enzymes is associated with the possession by these of two fundamental properties : (*i*) destruction by heat, and (*ii*) the capacity of bringing about change in a practically speaking indefinite amount of substrate. In these two properties we have a criterion whereby to judge whether any substance is enzymic in character. It was by following this principle that Bayliss and Starling were able to demonstrate enterokinase to be a true enzyme. We have seen that the cane extract is extremely rich in the possession of a substance or substances termed oxidases capable of stimulating a number of oxidations. It has been almost tacitly assumed by a large number of workers that the oxidases are enzymic in character. And the assumption has been mainly based upon the

fact that these bodies have been found to be sensitive towards heat. As to the second of the above properties, Jacoby's[1] is the only instance, who found that if the salicylic acid formed is removed by dialysis, the oxidase still possesses some activity. In direct contradiction to this, Medvedew[2] had observed that the oxidation of salicylic aldehyde to salicylic acid cannot be increased by an increase in the amount of oxygen present. It is difficult to reconcile Jacoby's results with this observation ; however, as pointed out by Kastle and Loevenhart, it is possible that the oxidases were present in very large quantities in Jacoby's solutions or those contained usually large amount of active intramolecular oxygen. Whatever may be, it cannot be said to have been definitel shown that oxidases are able to bring about change in an indefinite amount of the substrate.

Kastle and Loevenhart were the first who sounded a strong note of warning against regarding these substances as enzymes. The fact that a number of artificial oxidases have been prepared from time to time, which possess all the usual properties of oxidases, lends support to the suspicions of these workers as to the enzymic character of these bodies. Apart from their destruction by heat and a few poisons, but little is known concerning them which would lead us to regard them as of enzymic character. In fact they do not seem to act as oxygen carriers at all in the sense of being able to transform large amounts of oxygen from the air to the oxidizable substance. Again it seems never to have been satisfactorily established that they are real catalysts in the true sense. These doubts of Kastle and Loevenhart were confirmed by Euler[3] and Bolin who found that laccase is not of the enzyme type as it could be boiled for three minutes without destroying its activity. Doney-Henault[4] regards the oxidase action as catalytic but not diastatic, since it is variable or general and not specific.

[1] *Zeitschr. f. Physiol. Chem*, 1900, XXX, pp 135—148.
[2] Pflüger's Archiv., 74, p. 193.
[3] *Zeitschr. f. Physiol. Chem*, 1908, LVII, pp. 80—98.
[4] *Bull. del'Acad. Roy. de Belg.*, 1907, pp. 537—638.

It is rather strange that in face of these facts, the oxidases up till now continue to be regarded by a large majority of workers as enzymic. Our own experiments on the effect of boiling show conclusively that the oxidases are not enzymic in the true sense of the term. It is said that the activity of the boiled extract returns on keeping owing to the formation of a fresh quantity of the enzyme from the zymogen more resistant to heat. It is doubtful, however, whether any zymogen can withstand the effect of vigorous boiling for 15 minutes, much less of a further boiling the once boiled and cooled juice for the same time again. Again, we have been able to obtain guaiacum reaction from extracts of cane leaves which have been dried in the steam oven for six hours. Even the ash of these leaves gives a faint but distinct reaction. These facts lend strong support to the assumption that the oxidases are in reality "compounds" of some inorganic substance with certain colloids, which colloids do not seem to be proteins as supposed by Bunzel.[1] Similarly it has not been proved that the oxidases are able to act upon a practically indefinite amount of substrate. The author performed a number of experiments to test this point, which are still in progress. Using the alcohol precipitated oxidase as the material to work with and measuring the amount of iodine liberated, it was found that the reaction comes to a standstill after a time, although there is still a large quantity of the undecomposed hydriodic acid present; and shortly after this suspension of action, the opposite reaction due to reductase action begins and the amount of iodine liberated begins to be reabsorbed until no more of it is left. The problem involved in oxidase kinetics is too complex and requires more work for its elucidation.

However, the facts noticed by us, together with the observations of Euler and Bolin, Doney-Henault, and Kastle and Loevenhart, demonstrate clearly that these bodies are not enzymic in nature. In the face of such a mass of overwhelming negative evidence we are not justified in ascribing to these bodies properties which they do not possess.

---

[1] *Journ. Bio. Chem.*, XXVIII, 1916.

RHIZOCTONIA IN JUTE: THE INHIBITING EFFECT OF POTASH MANURING.

BY

R. S. FINLOW, B.Sc., F.I.C.,

Government Fibre Expert, Bengal.

In the course of an investigation into the manurial requirements of jute, *Corchorus* sp., which is being carried out at Dacca, some observations have been made, which seem to indicate a relationship between the incidence of *Rhizoctonia* in jute and the potash content of the soil. The results of the investigation, so far as they bear on this point, are presented in the following note in the hope that they may be of interest to the members of the Congress.

At Rajshahi on one occasion *Rhizoctonia* became epidemic in a seed crop of *C. olitorius*, which had to be cut in order to save it from destruction. At Dacca the disease became more serious each year up to 1916: it was especially liable to attack comparatively late-sown jute, such as pure lines which, as a precaution against loss through weather uncertainties, are not usually sown until there is no danger of damage from drought. So serious did the danger to the selection work on jute seem to be becoming that its removal from Dacca was considered. In 1916 in order to save the crop, extravagant manuring with cowdung and nitrate of potash was resorted to: this action had the desired effect and as the same thing had happened once before it was surmised that the attack might be due to malnutrition in the plant.

Soil types in Bengal.*

The soils of Bengal may be roughly classified into two widely differing main types, *viz.*—

(1) The old alluvium or laterite red soils.

(2) The new alluvium or river silt.

(1) *The old alluvium* forms a large and compact tract in Western Bengal, where it comprises large portions of the districts of Burdwan and Midnapore, and practically the whole of the districts of Birbhum and Bankura, bordering on the high lands of the Chota Nagpur plateau. Extending northwards it is found in the west of the Rajshahi District, whence it passes, like a broad red stream, into Bogra. Here it appears to divide, one branch known as the "Bahrind" tract, passing northwards into the Dinajpur and Rangpur districts, where it loses itself in the new alluvium, only to reappear in the Terai, in the north-east of the Rangpur District and in the adjoining portions of the Goalpara District of Assam. Returning to Bogra, the second branch passes eastwards, under the Jamuna or New Brahmaputra, into Mymensingh, where it reappears at Jamalpur and extends to the south-east, through the eastern portion of the Dacca District, and across the Meghna river, into Eastern Tipperah.

Broadly, the soils of this tract, though possibly not clays in the strict sense of the term, behave very like clay soils in that they become very sticky when wet and very hard when dry. They hold moisture badly so that they dry up rapidly; and cultivation is therefore very difficult and has to be concentrated into short intervals of time. Apart from their intractable nature, the red soils are very poor and are generally markedly deficient in both lime and phosphoric acid. Carbonate of lime is practically uniformly absent and the total lime content is often below 0·2 per cent. The phosphoric acid is often extraordinarily low, and samples have been examined in which the total phosphate is almost too small to be estimated. The percentage of total potash is

* A survey of the soils of the Province of Bengal is at present engaging practically the whole of the energies of the Agricultural Chemist and his staff.

about 0·3, which would not ordinarily be considered very deficient, and indeed does not appear to be so for other crops than jute.

The whole of the red soil tract is comparatively thinly populated in spite of the fact that it lies adjacent to—in the Dacca District, for instance—one of the most densely populated areas in India. In the Dacca and Mymensingh districts a considerable proportion of the red soil tract, known as the Madhupur jungle, is still under heavy sal (*Shorea robusta*) forest.

(2) *The new alluvium or silt.* These soils may be said to occupy the whole of the area in Bengal which is not included in the laterite. The silts vary greatly in composition ; but generally they exhibit the following characteristics :—

(*a*) They contain considerable quantities of lime (1 per cent. appears to be common), but little or no carbonate of calcium. In Western Bengal, however, and in isolated spots elsewhere, *e.g.*, in the Jessore District, from 3 per cent. to 4 per cent. of carbonate of lime is found.

(*b*) The potash content is normally high, and occasionally extraordinarily so, *e.g.*, in the Munshiganj Subdivision of the Dacca District, where the total potash approaches 2 per cent. Nevertheless, isolated areas containing little potash are to be found, *e.g.*, at Rajshahi in Western Bengal.

(*c*) Phosphoric acid is also present in sufficient or considerable quantities, and Mr. Davis, Indigo Research Chemist to the Government of India, informs me that phenomenally large amounts are occasionally found, as at Kotchandpur in the Jessore District and also in parts of the Terai.

Typical analyses of the two soil types are given below. The figures represent percentages soluble in hydrochloric acid (sp.gr. = 1·16) after 12 hours' digestion at 100°C.

	*Red soil (old alluvium) from high land of the Dacca Government Farm	River silt (new alluvium) from the Narayanganj Subdivision of the Dacca District
	%	%
Phosphoric acid P_2O_5 ...	0·04	0·23
Potash K_2O ...	0·30	1·27
Lime CaO ...	0·18	0·92
Magnesia MgO ...	0·38	1·47

* Analysis by Mr. A. A. Meggitt, now Government Agricultural Chemist, Assam.

There was no free carbonate of lime in either sample and the reaction of the red soil is acid.

Rhizoctonia is a genus of fungi of which representatives are to be found in every soil. Dr. Butler, Imperial Mycologist, classifies *Rhizoctonia* as a weak parasite, excepting under certain conditions, and experience with jute bears this out; for although isolated plants attacked by *Rhizoctonia* are commonly to be seen in the jute-growing tract, a serious epidemic, involving an appreciable proportion of any crop, has only been met with in certain tracts, such as the red soils of the Dacca District and, once, at the Rajshahi Farm.

The morphology and parasitism of *Rhizoctonia* has been studied by Shaw[1]: Shaw and Ajrekar[2] have also studied other forms of *Rhizoctonia* occurring in India. In the former paper Shaw concluded that *Rhizoctonia Solani* is the form which attacks jute (*Corchorus* spp.), and several other plants including sann-hemp (*Crotalaria juncea*), cotton (*Gossypium*, spp.), and Bimlipatam jute (*Hibiscus cannabinus*).

Rhizoctonia caused no trouble during the four years (1906-1909) in which the work on jute was carried on at Pusa (Bihar); but serious difficulty was at once experienced when the investigation was transferred to the red soil at Dacca in 1910. In the red soil tract it is the custom of cultivators not to sow jute on the same land oftener than two years in five, and it is considered that once in three years is safer still. On the other hand, on low-lying lands of the new alluvium, which the soil analyses quoted above show to be rich in potash, jute is often sown several years in succession.

MANURIAL EXPERIMENTS.

The first manurial experiments with jute at Dacca involved the use of the constituents which the soil analyses showed to be most deficient in red soils, *viz.*, lime and phosphate (East Shuti field

[1] Shaw, F. J. F. "Morphology and parasitism of *Rhizoctonia*." *Mem. Dept. Agric. India, Bot. Ser.*, IV, No. 6, 1912.

[2] Shaw, F. J. F., & Ajrekar, S. L. "The Genus *Rhizoctonia* in India." *Mem. Dept. Agric. India, Bot. Ser.*, VIII, No. 4, 1915.

experiments). The lime produced a remarkable effect, not only on jute and other *kharif* (monsoon) high land crops, but also on the *rabi* (cold weather) crops. An application of one ton per acre of lime increased the yield of jute fibre by about 300 lb. per acre : this is worth more than the cost of the lime, the application of which therefore gives a net gain in the first season. As the effect of the dressing lasts for about three years, the practice of liming proves a profitable one and will spread widely in the red soil tracts as soon as Co-operative Credit is sufficiently organized to develop it. The phosphates do not apparently influence the jute crop, either alone or in combination with lime ; nor did either lime, or phosphate, or the combination of these prevent a large number of plants from being attacked by *Rhizoctonia*. Nevertheless the results obtained were obviously good enough to encourage further investigation, and, in view of the acid nature of the soil, it was decided, in 1915, to ascertain how far more soluble and more drastic alkalis like the carbonates of soda and potash could reinforce the effect of lime. The whole experimental area (S. Mirpur field) received 30 maunds (about 1 ton) of slaked lime ; $3\frac{3}{4}$ cwt. (5 maunds) of ground rock phosphate, and 40 lb. of nitrogen, as castor cake, per acre. Out of six plots two received nothing in addition to the above ; two received 380 lb. carbonate of soda, and two plots received 500 lb. of carbonate of potash per acre.

The result was very surprising, as the carbonate of potash plots gave a mean yield of 33 maunds 28 seers (24 cwt.) of fibre per acre, a phenomenal yield for the poor soil of the Dacca Farm and one of the biggest crops ever recorded. The carbonate of soda plots yielded 27 maunds 35 seers (1 ton) of fibre per acre, nearly 6 maunds (4 cwt.) less than the return from the carbonate of potash plots and less than two maunds ($1\frac{1}{2}$ cwt.) better than the checks. Thus the effect of the carbonate of potash involved more than the mere neutralization of soil acidity.

More recent experiments with water hyacinth (*Eichornia crassipes*) have been described in a Pusa Bulletin,[1] which

[1] "Water Hyacinth (*Eichornia crassipes*): Its value as a Fertilizer," by R. S. Finlow and K. McLean. *Agric. Res. Inst. Pusa Bull.* No. 71, 1917.

give further proof of the value of potash manures for jute on the red soils of Eastern Bengal. It is not necessary to discuss this matter further here; but it will be interesting to trace the history of the South Mirpur series last year (1916), and in the present year (1917).

In 1916 it was decided to grow jute again on the plots in order to test the residual effect of the manures applied in 1915. Only a general manure (40 lb. of nitrogen per acre as castor cake) was applied; the season was a very bad one and a long drought in May 1916 permanently stunted the growth of the crop. The fields are given below and those for 1915 are included for purpose of comparison.

	1915		1916	
	Mds.	srs.	Mds.	srs.
Check (mean of duplicates)	27	35	11	2½
Carbonate of soda (mean of duplicates)	29	31	11	10
Carbonate of potash (mean of duplicates) ..	33	28	11	17

The yields in 1916 were thus, to all intents and purposes, identical.

In 1916 the Imperial Mycologist and the writer noticed that jute plots which had received potash, or the equivalent in water hyacinth, were freer, on the whole, from *Rhizoctonia* than those to which potash had not been applied. For instance, the potash plots in South Hazi field were not entirely *Rhizoctonia*-free; but there were, on the whole, considerably fewer affected plants in them than in other plots.

In order to throw further light on this important question, it was ultimately decided, as stated above, to sow jute again in 1917, for the third year in succession, in the potash series of plots in South Mirpur field. There was a twofold object in using this series. Firstly, it had been noticed that the oftener jute is sown in any given land the more liable the crop is to be seriously attacked with *Rhizoctonia*. An almost universal practice, which is the result of experience, exists among cultivators in the red soil tract, *i.e.*, not to sow the same land with jute oftener than twice in five years or, better still, once in three years. The series in question had already carried jute for two years, and 1917 being the

third season, it was therefore highly probable that *Rhizoctonia* would appear with some severity unless prevented from doing so. Secondly, it was thought that the potash-treated plots would, if *Rhizoctonia* is associated with potash shortage, show a comparatively greater resistance to the incidence of the disease than the plots not treated with potash.

Before sowing, the whole of the series received the following manurial treatment :—

Castor cake	40 lb. nitrogen per acre.
Bonemeal	55 lb. phosphoric acid (P_2O_5) per acre.

In addition the two potash plots received the ash of water hyacinth in quantity containing 200 lb. potash (K_2O) per acre. This is equivalent to a dressing of 370 lb. (4½ mds. or 3½ cwt.) of pure sulphate of potash per acre. The soda plots received 220 lb. per acre of carbonate of soda, equivalent to 130 lb. Na_2O per acre.

Sowing could not be done till the middle of May, which is very late, and the season was generally unfavourable. All the plots therefore suffered seriously, but the potash plots were, as the figures show, 100 per cent. better than the others.

Plot No.	Special treatment	Yield of fibre per acre Mds.	Srs.
A & D	Carbonate of soda (130 lb. Na_2O per acre)	4	0
B & E	Checks	3	0
C & F	Hyacinth ash (200 lb. K_2O per acre)	8	20

Rhizoctonia was rampant throughout the non-potash plots, which always contained about ten times as many diseased plants as the potash plots.

Plot No.	Special treatment of plot	No of diseased plants in portion of plot examined *	Approximate No. per acre	Approximate proportion of diseased plants (%)
(a)	Carbonate of soda	109	17,585	12·0
(b)	Nil	97	15,649	10·0
(c)	Hyacinth ash (200 lb. K_2O per acre)	12	1,933	1·3
(d)	Carbonate of soda	63	10,141	7·0
(e)	Nil	55	8,873	6 0
(f)	Hyacinth ash (200 lb. K_2O per acre)	6	968	0·6

* These counts were made by Babu A. L. Som, Mycological Collector, Bengal Agricultural Department.

There is little more to say ; but it is perhaps worth while to remark that a large number of plant ash analyses tend to support these indications of a connection between the incidence of *Rhizoctonia* and shortage of potash in the soil.

In collaboration with Dr. Butler an attempt is being made to extend this work in other directions and some suggestive results have been obtained.

THE SPRAYING OF TEA IN NORTH-EAST INDIA.

BY

A. C. TUNSTALL, B.Sc.,

Mycologist, Scientific Department, Indian Tea Association.

THE tea bush in common with other plants is subject to attacks of pests and blights. Although the appointment of special officers for their study has been comparatively recent, their treatment by spraying has been advocated in North-East India for more than twenty years. It is only recently, however, that the majority of planters have seriously considered it as a practical method for application on a large scale. The tea in North-East India is now being cultivated more intensively than formerly, and the losses due to pests and blights are in consequence receiving more attention. The occurrence of serious outbreaks of fungus disease in various districts has also emphasized the need for blight treatment on a large scale. In spite of the fact that from time to time experiments in spraying had been carried out on gardens, very little attempt had been made to adapt the machinery designed for use on other plants, and under different climates, to the special conditions found on tea gardens. The operations took up much time and attention. The amount of labour used was out of all proportion to the work done, and practical planters were justified in saying that spraying on a large scale was out of the question until improvements in machinery and organization had been made. The attention of this department was given primarily to effecting these improvements. Our department has not been able to do as much work on spray fluids as we had liked, as it was impossible to test them thoroughly

until improvements in machinery and organization rendered spraying on a large scale feasible.

As many have not had the opportunity of visiting a tea garden, it is necessary, first of all, to give a brief description of the manner in which tea is grown. The plants are usually grown from seed in a nursery and planted out when they are from 6 to 18 months old. They yield their first crop about the third year from seed, but do not reach their optimum yield for six or more years. The plants are pruned according to system with the idea of keeping the tops of the bush wide and of uniform height. The bushes are planted in regular lines, $4' \times 4'$, $4\frac{1}{2}' \times 4\frac{1}{2}'$, $5' \times 5'$, either square or triangular planting. The plants usually touch each other when well grown. At intervals, sometimes irregularly, shade trees are often grown. The ground is often irregular and cut up by open drains and nullahs. In some districts very steep slopes are planted, sometimes without terraces. As a general rule the use of large, wheeled machines is impossible. The tea is pruned in the cold season and plucked in the rains. The plucking of each bush takes place every few days. In the hotter districts, in the height of the growing season, it may be necessary to pluck every five or six days, while in the hills a fortnight or three weeks may suffice.

The climate of the tea districts varies in the different districts ; but in all the cold season is practically rainless, and there are two rainy periods—one in May or June, the other in July or August. From April to September there are showers almost every day.

On tea gardens spraying may be used for two things :—

(1) To increase the yield by lessening the attacks of those minor pests and blights which are generally present even on well-kept gardens.

(2) To deal with outbreaks of more serious diseases.

For the first purpose, it is desirable to add spraying to the general routine of tea culture. To obtain the maximum benefit from this treatment, it is necessary to consider the life-histories of the pests and blights concerned. Comparatively few can be dealt with satisfactorily by spraying in the cold weather. Besides,

much of the tea in many districts is so severely pruned that general spraying is hardly necessary. It would pay much better to search for and remove or treat all diseased leaves and twigs. A number of planters spray their pruned tea in the cold season with caustic washes to remove epiphytic organisms such as lichens. Some claim that this spraying is very beneficial. It would certainly be so in the colder districts, such as Darjeeling, where the lichens grow in profusion on the tea stems, harbouring many undesirable things. We have found by experiments, however, that solutions more caustic than 2 per cent. caustic soda are distinctly harmful to the tea plant. The best time to carry out general spraying is just before the first rainy period, and again in the less rainy weather which usually precedes the second period of heavy rainfall. During these periods the pests and blights are generally active and may check the growth of the tea most seriously. The heavy showers at other times in the rainy season interfere with the work so much that it is inadvisable to spray then, except in special cases, such as outbreaks of a serious epidemic disease.

The treatment by spraying of an outbreak of epidemic disease which has spread over a large area is at present practically impossible in the rainy season. The nature of the growth of the tea plant renders it impossible to prevent, by spraying, diseases attacking the young leaf, as the young shoots are constantly forming, and it would be necessary to spray about once a week. It would further be undesirable to spray the tea just before plucking, as the quality may be interfered with by the spray substances adhering to the leaf taken for manufacture. Before the young leaf is plucked a fresh growth of shoots has often commenced. To prevent the infection of this, it would be often necessary to spray before plucking. Preventive spraying at certain times of the year would therefore seriously interfere with tea culture. The only thing possible therefore is to watch for outbreaks and treat them when they occur. Unfortunately in some districts the gardens adjoin, and unless combined effort be made the disease or pest will be harboured on gardens on which no care is taken. This combination is not easily obtained, as all gardens are not affected to the same degree by the same

disease, and an expenditure on the treatment of a particular disease, which may be reasonable on one garden, may be unwarranted on the neighbouring one. Combined co-operative effort is essential to success in the treatment of some diseases, and we have attempted to get the planters in Darjeeling to carry it out. The scheme put forward was briefly as follows : A permanent spraying brigade, like a fire brigade, would be established in each district. The machinery, etc., would be housed in a central place under the charge of a competent Indian mechanic, who should be capable of keeping records, etc., in English, assisted by a number of sirdars, a sirdar being allotted for every 400 or 500 acres of tea. Whenever an outbreak of blight be reported, a company with sufficient equipment would proceed at once to the place. The mechanic in charge would arrange the details, such as water-supply, manufacture of solutions, etc., the actual spraying being done by gangs of coolies supplied by the management of the garden on which the outbreak has occurred, under the supervision of the sirdars. Whenever the brigade was not actually engaged in spraying, the staff would be at work systematically searching for outbreaks. The financial arrangements for this work would involve a deposit according to acreage towards capital expenditure and an advance for revenue expenditure. The spraying would be charged for at so much per acre, the price being sufficient to cover expenditure and provide a small interest on capital deposit. In this manner it would be possible to adjust the financial arrangements, so that gardens which are least affected by blights would have least to pay for their treatment.

The Darjeeling Planters' Association discussed the proposal fully and appointed a Sub-Committee to take active steps. This sub-committee proposed to test the efficiency of the blight brigade idea on an isolated garden, and if it proved successful, to extend it to a group of gardens, and so on. Unfortunately the war has made it impossible to carry out this so far, but the matter is not being dropped.

Although no large combined effort has yet been made, many gardens are adding spraying to their general routine, and many

more have only been deterred from doing so by the difficulty and expense of obtaining suitable machinery during the war.

A description of the spraying machinery and fluids employed on tea gardens may be useful to some who have to face similar problems.

Two types of sprayer have been used on tea gardens :—

(1) A heavy apparatus, forcing the fluid from a barrel to the nozzle through long flexible tubes.

(2) A light apparatus, carried on the back like a knapsack.

Our experiments have shown that the latter is more satisfactory. The long tubes of the barrel type damage the tea bushes, hinder the operators, and prevent their spraying the plants thoroughly. The apparatus is cumbersome, and more labour is required to do a given area in a given time than with machines of the knapsack type. All our attention has been devoted therefore to the latter.

Knapsack sprayers are of two kinds :—

(1) Those requiring continuous pumping.

(2) Those operated by a charge of compressed air.

Sprayers of the continuous pumping type have great drawbacks :—

(1) The attention of the operator is divided between the pumping and the direction of the spray jets. This is very undesirable.

(2) The operator is quickly tired, as he usually does much more pumping than is necessary to maintain the pressure.

(3) The working parts are small and hence delicate.

The compressed air type of sprayers has none of these drawbacks, and experiment has proved that it is the most useful type at present on the market.

There are two kinds of compressed air sprayers :—

(1) Self-contained, having an air pump fixed to the machine.

(2) With no pump attached, charged by a separate pump.

For spraying on a small scale the first kind recommends itself, as it is very handy. In choosing such machines, preference should be given to those having pumps of a comparatively large diameter, as they take less time to pump up.

For spraying on a large scale much time is saved by having machines without pumps attached and charging them from a single larger, powerful pump which may be used with a number of machines. Lately a further improvement has been devised. The latest machines are charged with air to a low pressure at the commencement of the operation only. The air is then further compressed by pumping in the spray fluid. The outlet is closed by a floating ball-valve which prevents the charge of air escaping. To recharge the machine with spray fluid it is merely necessary to pump in more spray fluid—no more air is required. This reduces the labour considerably, as in practice it takes much less time to charge with liquid than with air. This kind of machine is extremely simple. There is nothing on the knapsack portion likely to be spoiled by rough handling. The pumps are large and strong, and as there is only one set of pumps to a number of machines, a thoroughly capable man should be put in charge of them.

The nozzle is of great importance. Most of the modern nozzles produce the spray by giving the fluid a rotary motion. They differ principally in the means by which clogging is prevented. We have found that complicated nozzles with joints, springs, etc., are of no use, as they frequently go wrong and the coolies are not intelligent enough to put them right.

As it is important that the undersides of the leaves and twigs be sprayed, it is necessary to spray upwards as well as downwards. As this necessitates the nozzle being held close to the branches, it is important that the spray be produced as close to the aperture as possible.

The nozzles are generally used singly, attached to a brass tube about two feet long. The tube is often bent near the nozzle to facilitate the spraying of the undersides of the leaves and stems. With the single nozzle much depends on the good will and ability of the operator. The direction of the jet requires constant attention,

and unless the work is supervised thoroughly well, the bushes will not be sprayed properly. A considerable improvement has been brought about by using a number of nozzles so arranged that the direction of the jet is automatic, and all the cooly requires to do is to carry the machines down between the lines of tea, holding the nozzle attachment in front of him. We find four nozzles do this quite well. Very little more solution is required per acre than with the single nozzle, and the work is done more thoroughly. It has been found by experiment that it saves two-thirds of the labour.

The organization of the work has been paid a good deal of attention. The spraying machines required to be supplied with liquid. In most cases the spray fluids are supplied to the field in concentrated form, and diluted there with water from neighbouring nullahs or wells. In hill districts it is often possible to lead the water to convenient places, but in some cases water has to be carried considerable distances. It is important that the supply of spray fluids be so arranged that there is no unnecessary walking about. For instance. the number of bushes a machine can do with one filling may be ascertained by a preliminary experiment. Then, if an operator with a fully charged machine starts at the beginning of a row, and turns back down the next row when he has sprayed half the number of bushes the charge will spray, his machine will be empty when he is only one row away from his starting point; if the charging apparatus be conveniently placed, he may never have to walk more than a few steps to get his machine recharged. In this way it is possible to reduce the labour considerably, as the operators of the spraying machines are wasting the minimum of time in carrying their machines to and fro for charging.

The question of spray fluids most suitable for use on tea gardens is complicated by the fact that the leaves of the tea plant are used for human consumption. It is obviously undesirable to use anything poisonous to human beings as a spray fluid. Arsenical preparations cannot be employed, although copper solutions are quite harmless, as the amount of copper contained in a cup of tea made from leaf sprayed with them is found to be too small for detection by ordinary

methods and quite harmless. Our experience has shown that it is impossible to get solutions requiring accurate measurements and careful preparation made satisfactorily on tea gardens. We are therefore devoting special attention to ready-made preparations.

This year we tested a number of these, and our observations showed that lime-sulphur solutions were on the whole the most satisfactory, both as fungicides and insecticides. They are very easy to use and not likely to cause such troubles as clogging nozzles. Fluids which contain solid particles or emulsions which require stirring are not advisable, for unless the supervision is very good, the coolies will not keep them stirred when charging the machines, with the result that some machines get more concentrated fluid than others.

In spraying operations carried out on tea gardens simplicity is essential. Nothing must be left to the good will and intelligence of the cooly. The only machines likely to prove useful are those which require no special attention. The manager of a large tea estate has so many things to attend to that he cannot spare the time to supervise any one set of operations personally during the whole time those operations are being carried out.

Lately some attention has been paid to dry dusting powders. We have not had much success with them so far, but if suitable powder can be invented, this is by far the most economical form of spraying. We have tried various forms of "Bordeaux" powders and mixtures of slaked lime and flowers of sulphur. The latter seem to be more satisfactory than the more expensive powders containing copper compounds.

SOME FACTORS AFFECTING THE EFFICIENCY IN THE USE OF CANAL WATER.

BY

W. ROBERTS, B.Sc.,

Professor of Agriculture, Agricultural College, Lyallpur

AND

O. T. FAULKNER, B.A.,

Deputy Director of Agriculture, Lyallpur

THE Punjab is pre-eminent with regard to the amount and scale on which crop production is dependent on large Government canals. Of the total irrigated area of 22,000,000 acres, over 9,000,000 acres are irrigated from canals. In the greater part of this canal area the annual rainfall is from 5″ to 12″ and the water table is from 20 to 80 feet below ground level. The soil is alluvium, and may be classed as sandy loam, though a good deal of variation occurs. Crops are thus, especially in winter, almost entirely dependent on irrigation for their water-supply. The canals are perennial; but as the river supply in winter is low the quantity of water carried in the canals in that season is subject to very wide variations which cannot be altogether foreseen. Thus, in the Lower Chenab Canal the normal full supply is 10,000 cusecs, but in 1916-17 the discharge was at one time under 4,000 cusecs. At present five big canals are linked together, *viz.*, the Upper and Lower Jhelum, the Upper and Lower Chenab, and the Lower Bari Doab, and these are mainly dependent on supplies in the Jhelum and Chenab rivers. The river supplies drop sometimes rapidly in October and November, and render it difficult to get the full area under wheat which is the main crop of the Punjab canals. The critical period is during October and November,

especially during the latter month, as on the water then available will depend the area sown. With the full area sown, the problem is to utilize the canal supply to the full in maturing the crop.

The system of water distribution and the orders regulating it, with a view to making the best possible use of the water, are admirable, and reflect great credit on the Irrigation Department. The main principles of these are given below :—

1. The supply of water is given on a basis of 75 per cent. (in some cases 66 per cent.) irrigation per annum, *i.e.*, 50 per cent. ot the land to be cropped in the *rabi* (winter) and 25 per cent. in the *kharif* (summer). This is all the Irrigation Department guarantee. In practice on most canals the cropping is 100 per cent., and often more.

2. When river supplies are low, the canals and their various branches are run in rotation, so as to keep them as full as possible. This prevents excessive proportionate losses by seepage and enables all the area to be commanded in rotation.

3. The water is divided up from main canals to branches, minors, and distributaries. The supply for the cultivators is generally carried by a water-course from the latter. Water-courses carry about 1½ cusecs ; which quantity, it has been found, can be handled most economically by the cultivator.

4. The land is divided up into squares of 25 units. (Sometimes these units are *killas* [a *killa* = 1·1 acres], but in the latest canals the square is 25 acres.) Each unit or acre has to be divided into 8 compartments, or *kiaris*, in direct contact with a water-course. There must be a water-course on either side of the acre unit to ensure water being taken direct into the *kiari*. Roughly, a water-course carrying 1½ cusecs commands 400 acres. Cultivators irrigate by turns of three hours, or *pahars*, based on the area, and in such a way that if the canal is running continuously each holder of a square or half a square gets his turn every 10 or 12 days. This regulation enables a cultivator to irrigate when necessary, and does not force him to irrigate prematurely, as would be the case if the turn, or *wár*, took much longer than 10 days. This is a very important point, especially in the *kharif* season.

It will be convenient if we discuss the present sources of loss or inefficiency under three heads, *viz* :—

I. Losses due to the nature or construction of the canals.
II. Losses by inefficient distribution.
III. Losses in the field.

I. The canals generally flow along the ridge of the *doab*, or tract between two rivers. Seepage through the sandy bed is enormous and constitutes the chief source of loss. Kennedy estimated the loss by seepage in the main canals and branches as 33 per cent. of the water entering the canal, while another 33 per cent. was lost in distributaries and water-courses, leaving only 33 per cent. for the field. These figures are perhaps excessive, but it is generally believed that at least 50 per cent. of the water is lost before it is applied to the field. This problem is mainly an engineering one, and the present regulations with regard to running the canals full, avoiding silting and scouring, etc., have been evolved to minimize these losses. Of late some work has been done by way of "lining" canals to prevent seepage and water-logging, the latter having become acute in places.[1] When considered from the point of view of the real value of the cusec, "lining" appears to be a very paying proposition, and, though a great deal of work remains to be done before it can be properly decided what material to use, it is certain the future must show development in this direction. What is wanted at present is concentration of experiments on one canal and the setting of the chemical or physical research work on a permanent basis.

Another source of loss, which is connected with the design of a canal, is dependent on the intensity of irrigation proposed. If the intensity is low the proportion of losses in channels becomes excessive, and the canal as a whole, in consequence, less efficient than if the water were concentrated on a smaller area. Some evidence on this point has recently been brought forward by Gibbs in a private communication.

II. The second main source of loss, while mainly concerning the Irrigation Department, also touches on revenue and agricultural

[1] *See* Paper on "Cost of lining canals," by Curry, Punjab Irrigation Congress, 1917.

aspects. The system of distribution and the rules with regard to *khal kiari* represent the practical results of Kennedy's and other Irrigation officers' work in this branch. The most recent work of importance in this line has been that of Mr. A. S. Gibbs, who has brought out several papers on the subject within the Department It is a great pity they have not been given wider publication. The main tendency of late has been to concentrate on equable distribution either by use of Kennedy's "outlet" or a "module," such as Gibbs' module. The importance of this aspect of the question may be gauged from Gibbs' figures in one of his papers, where on the Lower Chenab the allotted area per cusec varied from 380 to 180 acres and the efficiency of irrigation from 100 per cent. to 67 per cent. The difference between the efficiency of various classes of cultivators was in the region of 9 per cent. as a maximum. These results are very instructive, but a great deal more work is necessary: for in cases where the allotted area per cusec is small the cropping will be different, and crops requiring a large amount of water, *e.g.*, sugarcane and *senji* (*Melilotus indica*), would be largely grown. The value of the return per acre will be similarly affected.

III. The third main source of loss, *i.e.*, by irrigators and in the field, is the most difficult to control, and by far the most complicated part of the problem, since many factors are involved. In the first place, it is not always easy to define what constitutes a loss and what constitutes a saving. For instance, it is roughly realized by Irrigation officers and many cultivators that some part (though by no means all) of the wheat crop of this province could be brought to maturity with a fair return, sometimes even a maximum return, by the application of only two waterings after sowing, *i.e.*, one in February and one in March. Even one of these may in some years be replaced by rain. This has been more definitely shown by various experiments.

The experiments conducted by the Irrigation Department have led to three waterings, after sowing, in the absence of rain, being accepted as more or less the standard all-round figure for the Punjab canals. For a rough, but safe and widely applicable, generalization,

this is shown by experience to be the right figure. Experiments[1] and experience at Lyallpur have led to the conclusion that two well-timed waterings, with good cultivation and harrowing, as above, will suffice an average land in some years in favouring circumstances ; but not otherwise. An experiment conducted by Rai Sahib Sewak Ram at Gangapur[2] has shown that on very good land, well cultivated and harrowed, a moderate crop was obtained with only one watering assisted by very timely rain in March. These results cannot, however, be regarded as applicable to all lands ; for on many fields an earlier watering becomes absolutely necessary to protect the wheat against white ants or *kallar*. None the less, there are undoubtedly cases in which zemindars, having the water available, do apply it to wheat crops in December and January, when a fair, if not a maximum, crop could be grown without it. But supposing that by not doing so a watering is "saved" ; nothing has been achieved unless this water can be put to some more profitable use. This is a much more difficult problem ; for the only obvious way in which it could be profitably used is on a leguminous winter crop (such as *senji* or *shaftal**) grown for fodder or green manure. But such a crop would have to be sown in October and November, just at the time when water is most badly needed. Thus, rather paradoxically, the problem of using any surplus January water becomes a problem of saving water earlier at the critical sowing time. The matter is further complicated by the extreme uncertainty of the January supply.

Another way in which the Punjab Agricultural Department has shown that water can be saved, possibly with benefit to the crop, is by delaying the first watering to American cotton or to early sown country cotton. Full experimental data are not yet available ; but crops of cotton sown in lines have been maintained by repeated interculture in a thoroughly healthy condition until June or even July without watering, and have subsequently given

---

[1] *Experiments, etc., at the Agricultural Station, Lyallpur, Punjab.*

[2] Howard, A., and Howard, G. L. C. "Report of the Imperial Economic Botanists." *Scientific Reports of the Agric. Res. Inst., Pusa*, 1916-17, p. 31.

* *Trifolium resupinatum.*

yields well above the average. This is sufficient to indicate at least a possibility of water saving in this direction. Again, however, it cannot be said that a saving has been effected until profitable use is made of the water. But in this case the problem is not quite so difficult, as sugarcane and fodder crops at this time make considerable demands on the water-supply, whilst any spare water could be profitably used for the breaking of fallow lands, or the growing of leguminous crops for produce or green-manuring.

In the areas irrigated by Government canals such as those of the Punjab, there is one enormous advantage in the hand of the would-be recommender of "water-saving" methods, *i.e.*, methods by which the water can be more efficiently used. This advantage lies in the fact that if the recommendations are really sound and the recommender is really convinced of their soundness, he has not to face the necessity of convincing thousands of cultivators of the truth of his remarks: he has only to convince the Irrigation Department and other Government officials concerned, as to the wisdom of the recommendations and to indicate exactly the advantages to be gained. A large-scale experiment can be initiated, and in the event of success the Irrigation Department should be able in time so to modify their system or regulations regarding supply, as to render the desired changes profitable to the cultivator, and thus ensure their adoption. Nor need there be any hesitation in making such a change if the case for it is sound, for the existing systems have not, as in many parts of India, been adapted in the course of centuries to the natural conditions or to almost equally stable economic ones. The system of agriculture followed under canal irrigation is one worked out by the cultivator in less than a generation to suit the amount of land and water given him and to meet newly arisen economic conditions; and so long as any further change is really sound, *i.e.*, really to the cultivator's benefit, he will not long maintain any objection to it. Moreover, new canals can be designed in accordance with the most up-to-date knowledge.

But this same facility by which improvements could be introduced lays a great responsibility on experimenters and upon Government, to see to it that all the effects of any proposed change,

the limits of its applicability, and its real exact value, are completely worked out before any action is taken. For instance, it has been pointed out above that there is a possibility of saving a certain, but as yet very indefinite, amount of water in the mid-*rabi* season. But our experience at Lyallpur has equally shown that this by no means applies to all land. And to work out the limits of the applicability of this is infinitely more difficult than demonstrating that it can be done in some cases. The extent to which it applies can only be ascertained by very detailed investigation and thorough soil surveying. But, again, this water when "saved" represents a "gross" saving ; there are some debit items which have to be considered and worked out.

To withhold water from a field which by moderate cropping and very good cultivation has been brought into and maintained in a really good tilth, is a very different matter from withholding it from a crop growing on land which, from heavy cropping and less expensive cultivation, is not in such good order. Thus the "saving" costs something in fallowing and cultivation. This opens another broad field for investigation which is as yet untouched. Again, there is evidence that what applies to a late sown crop does not necessarily apply equally to an early sown one ; and thus, again, the effects of early and late sowing on the subsequent water requirements of the crop must be considered and investigated. This is a matter of much importance, for in most years the length of the sowing period is considerable, and there is a possibility of it becoming even longer in the future.

Another somewhat similar factor, which also has to be considered and possibly to some extent investigated, arises from the fact that all fields cannot be irrigated at the same optimum times, and an irrigator often wisely applies water earlier than would otherwise be necessary simply for this reason. The problems connected with making a profitable use of such water when it has been "saved," have already been touched upon.

Very similar, though somewhat less difficult, factors arise out of the water-saving in regard to cotton in the early stages, of which we have already indicated the possibility.

It will thus be seen that very extended and detailed investigation is necessary before we can widely translate into practice even very simple principles which have been realized and explained by the Agricultural Department for some years and are already somewhat recognized outside.

These are the problems involved in making the best possible use of the present canal supply, if this be accepted as unalterable. But the supply available for irrigation would be greatly increased if any great extent of the canals and branches were lined. Moreover, there is always much water running uselessly down the rivers in the summer, some of which might possibly be taken into the present canal areas by enlarged and lined canals. For the working out of the economic results of any possible change in this direction we need much more data than are yet available ; and it would involve the study of systems of more intensive agriculture than those yet followed, together, probably, with a change in the direction of more stock-rearing.

It will thus be seen that the problems involved in making the most efficient use of the water-supplies in our Punjab rivers are very broad, and much bigger than those with which Agricultural Departments have generally been concerned.

The agricultural investigator usually has little power to vary any of the great factors governing the agricultural practices—such factors as the value of land, the water-supply, the temperatures, and the cost of labour being beyond control. In these irrigated tracts we can control the water-supply within considerable limits ; this puts the value of the land under some control, and even gives us some choice in the matter of temperature, since to some extent there is a choice between *kharif* and *rabi* cropping. And in view of the great capital value of the canals and their enormous effects, present and potential, on the prosperity of the province, the problems involved are well worthy of adequate and early investigation and real research.

THE PHYSICAL TEXTURE OF SOILS IN ITS RELATION TO CROP PRODUCTION.

BY

D. CLOUSTON, M.A., B.Sc.,

Offg. Director of Agriculture, Central Provinces,

AND

A. R. PADMANABHA AIYER, B.A.,

Offg. Agricultural Chemist, Central Provinces.

It has been said that " No industry is so profitable or yields such abundant returns in proportion to labour expended as agriculture : for the work is done by natural forces ; all that man has to do is to supply the conditions and give the powers of Nature free scope. It is very different from manufacture, where every rivet has to be hammered into place and every finish attended to by labour and design. In growing crops the main work and all the design is carried out for us. Wherever there is sun and air and any kind of soil, there crops can be grown ; for fertility of soil is largely a matter of treatment."

The tendency in the Central Provinces and other parts of India where agriculture is backward is to rely on the existing fertility of the soil, to reduce the amount of treatment given to a minimum, and to allow areas of so-called inferior soils which do not respond to careless methods of treatment to remain uncultivated. In the Central Provinces there are large areas of lateritic soil most of which is lying waste at present and which is considered to be below the margin of profitable cultivation. Small areas of this soil brought under cultivation are cropped with *kodo* (*Paspalum scrobiculatum*), one of the most inferior crops grown in the Provinces. This lateritic

soil is locally known as *bhata*, and its purchase value is from Rs. 3 to 3-8 per acre. This *bhata* is of a coarse, gravelly texture, and the mechanical analysis shows it to contain 69 per cent. of gravel and stones and only 31 per cent. of fine soil, as against 4 and 96 per cent. of gravel and fine soil, respectively, for black cotton soil. The enormous possibilities of this lateritic soil have only lately come to light as the result of the opening of a Government Farm at Chandkhuri, the soil of which is nearly all pure *bhata*. A small part of the farm area consists of rather heavy soil (a clayey loam) known locally as *dorsa*. The results of the mechanical and chemical analyses ot both these soils are given in Table I.

TABLE I.

Showing the mechanical and chemical analyses of bhata *and* dorsa *soils of Chandkhuri Farm, Raipur.*

	Bhata soil	Dorsa soil
Stones and gravel	69·00	11·40
Coarse sand .. .	9·88	5·09
Fine sand	5·22	4·03
Silt	4·95	20·31
Fine silt	3·63	18·71
Clay	4·60	31·11
Moisture	0·68	4·38
Loss on ignition	2·04	5 56
Carbonates	0·08	0·11
	100·08	100·70
Nitrogen	0·025	0·056
Phosphoric acid total	0·048	0·011
Available do	0·007	traces
Total potash	0·527	0·910
Available potash	0·080	0·110
Calcium carbonate	0·080	0·110
Organic carbon	0·159	0·200

PLATE VI.

Fig. 1. SUGARCANE ON BHATA.

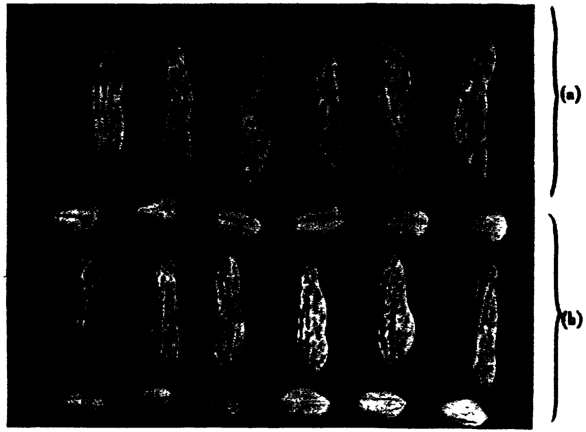


Fig. 2. GROUNDNUT GROWN ON (a) BHATA, (b) BLACK SOIL.

Fig. 3. INDIGO ON BHATA.

Fig. 4. INDIGO ON BLACK SOIL.

From the table it will be seen that *bhata* soil is poorer in nitrogen, phosphoric acid, and lime than *dorsa* soil. The biological analysis of *bhata* shows that, though it has been lying waste for an indefinitely long period, it has got the necessary mycroflora required for the decomposition of the organic manure added. The ammonifying capacity of this soil is quite good : the nitrifying power, though not so good as that of black soil, is also fairly good considering the fact that it has never been manured or cultivated.

Bhata readily responds to manuring and irrigation and will be much improved by cultivation. This fact has already been brought to light from the field experiments carried out at Chandkhuri Farm where, with irrigation, this soil has given under agricultural treatment much larger yields than black soil. This is due almost entirely to the fact that the soil is porous. Its porosity ensures good drainage, good aeration, and oxidation, conditions of special advantage to nitrification. These conditions are not met with to anything like the same extent in our richer but heavier classes of soil.

Manure applied under these conditions is utilized to the best possible advantage. Given irrigation and manure, we have in such a soil all the conditions which make for the healthy development of the plant. Plate VI, fig. 1 shows a crop of cane grown on *bhata* which yielded over 40 tons of stripped cane per acre. This class of soil produces not only larger crops of cane, but cane which is entirely free of red rot, to which this crop is so subject when grown on the less well-aerated and well-drained black soils.

Groundnut has done equally well, out-turns of 2,400 lb. per acre having been obtained from plots manured with basic slag. The actual acreage out-turn of groundnut grown on *bhata* is nearly twice as great as that ordinarily obtained from the richer but less porous black soil. Plate VI, fig. 2 shows the relative sizes of the same variety grown on *bhata* and black soil in the same district.

Plate VI, fig. 3 shows a field of indigo grown this year on *bhata* soil on the Chandkhuri Farm. The plants have not only

grown to a satisfactory height, but they have produced a good yield of seed. On the black cotton soil on the Tharsa Farm the same crop is less promising, as Plate VI, fig. 4 shows. Here, again, we attribute the difference to better aeration in the *bhata*, for the climatic conditions do not differ to any extent on the two farms.

The average acreage out-turn of *deshi* cotton on black soil in the cotton tract last year was approximately 180 lb. of *kapas* (unginned cotton) per acre : it will be less by about 20 lb. of *kapas* this year. The low out-turn of last year was due to the heavy and continuous rainfall in August and September ; while this year the poorness of the crop is due to the excessive rainfall in the last half of September and the early part of October. Cotton grown on *bhata* on the Chandkhuri Farm (Plate VII, fig. 1) did not suffer last year, as may be gathered from the fact that Cambodia yielded 783 lb. of *kapas* per acre and the crop is almost equally good this year. We have then, in *bhata*, a soil which is well aerated and drained throughout the year and which under irrigation is independent of the vagaries of the rainfall.

Plate VII, fig. 2 shows a crop of *juar* (*A. Sorghum*) grown in a small area of black soil on the Chandkhuri Farm. The crop looked pale and yellow during the rains, due evidently to nitrogen-starvation on this richer but heavier soil. Plate VII, fig. 3 shows a crop of *juar* grown the same year in an adjoining *bhata* field on the same farm. This crop was not only of a healthier colour but grew to a much greater height.

In India there are many millions of acres of waste land of this lateritic soil known under different names, but all possessing the qualities which make for the healthy growth of our most profitable crops. In the Central Provinces alone there are about $1\frac{1}{4}$ million acres of cleared and partly cultivated land of this class, in addition to a still larger area of the same soil at present classed as "jungle and waste land."

How far these can be utilized for this purpose will depend on the irrigation facilities available. It is worth while considering

PLATE VII.

Fig. 1. COTTON ON BHATA.

Fig. 2. JUAR ON BLACK SOIL.

Fig. 3 JUAR ON BHATA

whether it would not be possible to provide irrigation either by tapping sub-soil water or by constructing irrigation channels and tanks which would command such areas. Such areas undoubtedly possess great potentialities for the economic development of the agriculture of this country. At present prices the out-turn of Cambodia grown on *bhata* land last year was worth Rs. 217 per acre. The cost of cultivation, including a water-rate of Rs. 5 per acre, did not exceed Rs. 25. No manure was applied as cotton was grown in rotation with cane, for which the land had been manured the previous year.

The yields of cane obtained have varied from 25 to 40 tons per acre. The manure applied was 10 tons of sann-hemp or cattle-dung followed by a top-dressing of 1,600 lb. of *til* (sesamum) cake. The value of even 25 tons of cane when made into *gur* in the Provinces is Rs. 420. The cost of producing this *gur* (raw sugar) does not exceed Rs. 200. These are only two of several crops which have been tried and found to give, with irrigation, large and profitable yields on this porous and well-aerated lateritic soil. Most of this soil is lying waste at present. When it is cropped, as it sometimes is with *kodo*, the gross value of the crop per acre is about Rs. 10, but even *kodo* is grown on this soil only at intervals of two or three years; the land is allowed to lie fallow in the intervening years, so that the gross value of the annual yield per acre does not exceed 3 to 4 rupees. Under the climatic conditions which obtain in the Central Provinces, where we have a 3½ months' period of very heavy rainfall, from the middle of June till the end of September, at which time all our *kharif* (monsoon) crops are on the ground, the extent to which waterlogging checks the growth of these crops is very great. Soil drainage is not practised to any extent by the cultivator and he is at the mercy, in consequence, of the rainfall. We venture to say here that Mr. and Mrs. Howard of Pusa and Mr. Hole of Dehra Dun have done India a great service in focussing our attention on the importance of drainage and soil aeration as soil factors which count for even more in crop production than manuring. The time may yet come when, with the extension

of irrigation facilities, these lateritic soils, which in the Central Provinces at least are at present considered to be below the margin of cultivation in most cases, will be treated as garden land of the best quality. Given water, all that is required for such soils is cultivation and manure : we can rely on nitrifying organisms to do the rest.

FOREST GRAZING AND THE NELLORE "KANCHA" SYSTEM.

BY

CECIL E. C. FISCHER,

District Forest Officer, Nellore.

The grazing of cattle in the forest is admitted to be a detrimental practice from almost every standpoint. Apart from the injury to the forest itself, and thereby to the dependent interests, it has all the objections of promiscuous and communal grazing.

These facts and their remedies have been urged for a long time by foresters in India, but very little weight has been given to their opinions which are generally looked upon as highly coloured and biased. It is only recently, at least in the Madras Presidency, that steps towards an intelligent policy of improvement have been taken. How far this has come about through the insistence of forest officers it is difficult to judge, but it seems clear that more attention is accorded to the opinions of others on the subject. It will be useful, therefore, to quote the words of an agricultural officer who has expressed the gist of the matter more eloquently than I can hope to do. In his report on his Cattle Survey of the Madras Presidency, Mr. H. C. Sampson wrote : " It is a noticeable fact that the nearer cattle are to the forests, the more degraded the type. Here one sees all the evils of mixed grazing........Forest grazing is always a serious menace to the forests and not only to the forests but to the water-supply of wells and tanks........Grazing and forestry are, and must be, at variance ; for, as the forest canopy increases, the grass tends to disappear and the simplest way of lessening the shade and increasing the grass is by forest fires."

It is not necessary to dwell further on either of these two aspects of the evil.

Unfortunately, in most parts of India, at all events practically throughout Southern India, it has been customary for the people to send at least their inferior cattle to graze in the forests, and no sudden stoppage of this practice could be contemplated.

In some parts of the world some kind of compromise has been arrived at and a silvo-pastural system has been evolved under which the growing of trees and the production of fodder-grass go on side by side. But it is only a compromise and, moreover, premises the most favourable conditions of climate and human co-operation. All these circumstances are absent in India, nor could even the human co-operation be hoped for short of a considerable period of education.

In order to devise remedial measures it is necessary to understand thoroughly the routine of the objectionable practices. Where some attention has been paid to the breeding of cattle, the breeders themselves have introduced restrictions. There the better class of cattle are stall-fed, or at least carefully segregated and grazed on the land in numbers not exceeding the feeding possibility of the area. In other localities, and in even these as far as the excess cattle maintained for manure or for the prestige of ownership is concerned, there is no such restriction. The number of cattle is far in excess of that which can find sustenance on the land. Large herds have to find what food they can, with the deplorable results inseparable from communal and excessive grazing.

To add to the disastrous position, that unsavoury enemy of vegetation, the goat, until recently was rampant. It is only within late years that this animal has been excluded altogether from Government forests.

The remedy for this state of affairs lies clearly, firstly, in the reduction of what may be termed the "drone" cattle to reasonable limits and the segregation of the different classes so as to avoid the evils of promiscuous breeding ; and, secondly, in providing ample fodder for all.

There actually has existed from before the days of the British occupation an indigenous practice of this kind in the Nellore District, and this has given a direction for the policy of the future.

The Nellore District forms a comparatively narrow belt along the Bay of Bengal, stretching for about 140 miles, starting about 40 miles north of the presidency town. On the west it is bordered by a low chain of mountains known as the Veligondas. Between this range and the sea, a distance of 50 to 60 miles, spread plains dotted with hills of gradually diminishing elevation and furrowed by numerous rivers and streams. Near the coast, and adjoining the many tanks, there are stretches of rich arable soil, but by far the greater portion of the area consists either of ocean sand, dry gravelly or quartzose soils of small fertility. A fair proportion, including most of the hillocks, is occupied by so-called forests. These are of the poorest type and are made up mostly of thorny shrubs such as *Carissa spinarum*, Randias, etc. They present ample evidence ot the goat-browsing, over-grazing, and ruthless hacking of the past. Such are the areas in which the forest officers, until recently, have been inhibited from imposing salutary restrictions in the direction of limiting the number of head to the available supply of fodder, with the result that the areas have been further degraded instead ot being improved after being brought under forest reservation.

It is perhaps a matter for surprise that this district is the home of the famed Nellore or Ongole breed of cattle and that so fine a breed could be raised alongside the desolation I have attempted to depict. But the best class of cattle are bred mostly in the coastal tracks where they are either stall-fed, grazed on the fields when lying fallow, or pastured on private lands earmarked for the growing of fodder under the strictest surveillance. It is only the miserable excess cattle, and of course the goats, that are responsible for the injury stated.

The areas reserved for the better cattle are enclosed within fences and are known locally as *kanchas*. They are given a period of rest during part of the year and only a strictly limited number of cattle is admitted at other times. The period of rest coincides with the time when, after the break of the south-west

monsoon, the new grass is growing and the fields are not yet under crop, so that the latter are available for pasture. By the time the cattle must be driven from the fields the *kanchas* are ready for them, to be closed again when the stubble left on the fields after the harvest invites them afresh.

Owners of such grazing blocks who are in a position to admit the cattle of others demand high rates for the privilege. The fallow areas in the wet land tracts are insufficient for all the cattle when the fields are closed to them, and there sets in then a temporary emigration towards the hills, the beasts returning only after the harvest.

This is the "Kancha" System which, during the past three years, has been extended to practically all the Government forests in the plains of the district. For climatic and irrigational reasons the slopes of the Veligondas have not been included in the scheme, the hills are closed to grazing and the cutting and removal of grass alone is permitted. The plains forests have been divided up into blocks of convenient size, varying from 60 to 3,000 acres. Each block or *kancha* is put up to auction in May for the ensuing grazing season at an upset price of 4 annas per acre. As far as possible the village limits are adopted as the boundaries of the blocks so as to induce the village as a whole to purchase the lease for the use of the village itself. Here and there speculators take up a block or two with a view to making a profit on the migrant herds from the wet belt, the owners of which are willing to pay a comparatively high rate for ensured and safe pasturage of their valuable cattle.

The *kanchas* are handed over to the purchasers on the 1st July although they remain closed to grazing for another 2½ to 4 months according to seasonal variation. When grazing starts, the incidence is limited to one head of horned cattle (bulls, bullocks, cows, and buffaloes) for every two acres or one sheep per acre. It will be seen, therefore, that the grazing costs at least 8 annas per head of horned cattle or 4 annas per sheep. The majority of the *kanchas* sell for 4 annas per acre or a trifle more, but a considerable proportion, owing to local conditions and competition, fetch a good deal more, culminating in one instance at Rs. 4 per acre. This rate is in extraordinary contrast with the nominal fee of 3 or

4 annas per cow or bull, 6 annas per buffalo, and $1\frac{1}{2}$ or 2 annas per sheep, which was the grazing fee for the whole 12 months under the old system of unlimited grazing on individual permit.

From the date of opening the *kanchas* may be grazed upon until the end of April, after which they are closed again just before the first premonitory showers before the monsoon are expected. Sheep are not admitted simultaneously with horned cattle, but only after the latter have quitted late in the season.

An important feature of the system lies in the fact that the protection of the *kancha* against malpractices of all kinds is left almost entirely to the lessee, who is directly responsible and may be fined or even have the lease cancelled should he default in this matter. The lower subordinates of the Forest Department are forbidden to interfere in any way, except to assist at the direct invitation of the lessee.

With some of the blocks, in addition to the area open to grazing, the lessees undertake the protection of adjoining areas that are closed for regeneration or for other reasons. For the successful protection of these closed areas the lessee is permitted to cut and remove grass or in lieu is entitled to a rebate of one anna per acre so protected.

In recognition of their efforts the lessees whose protection has been effective, receive rewards of from 5 to 10 per cent. of the purchase price of the block according to the degree of protection extended, and the most meritorious are awarded silver medals in addition.

The lessees are provided with printed permit forms. No cattle should be found within the block without a grazier in charge and the latter must be furnished with a form signed by the lessee covering the number of animals in his care.

The eventual aim is that the leases should be taken up by the village as a corporate body and managed by an elected council or *panchayat*. In this way the people will be invested with a measure of local self-government and become the protectors of their forests and their own interests therein. Without such co-operation protection would be hopeless.

The forests open to grazing under this system are not necessarily devoted to grazing alone. Many are being worked simultaneously for the provision of fuel and small timber on a rotation by small areas. Each annually worked area, or *coupe*, is closed for a period of ten years, following the year of felling, to all grazing or extraction. Each *coupe* is surrounded by a fencing of dry thorns, which is constructed as the work of felling proceeds, so that the fence is complete by the time the produce has been removed. As a rule it is these areas that the *kancha* lessees undertake to protect in addition to the block leased for pasture.

But little reflection will make it clear that the final word has not been said when we have reached the stage described hitherto. We have seen that intensive grazing and the existence of forest growth on the same area are incompatible. Excessive grazing means the more or less rapid extinction of the trees and shrubs, while the preservation and increase of woody growth entails the gradual diminution and disappearance of grass. It follows that the management detailed cannot go on in perpetuity and further steps must be taken if a permanent supply of fodder grass is desired. Such measures are actually contemplated. The plains forests of Nellore are being classified into fuel and fodder areas according to local demands, their actual condition, and the quality of the soil.

The management of the fuel areas will continue as laid down previously, but the fodder reserves are to be treated differently. Here annual *coupes* will be felled over, but the trees left as standards will be not more than 10 per acre and will be selected for the purpose of affording shelter for the cattle against sun and rain and regardless of their qualities as yielders of timber, fuel, or other produce, so that species generally considered as quite useless from a forest point of view—for example, *Dalbergia paniculata*—may well be selected so long as they have an ample crown. The fellings also will be so conducted as to discourage regrowth by coppice shoots.

Following on the felling, operations will be undertaken for the extraction of prickly pear and other thorny growth. In the following year the seeds of good fodder grasses will be sown in the areas thus freed of thorns. The *coupes* thus treated will be closed to grazing

for a period of 2 or 3 years so as to establish thoroughly the new grass.

By these operations it is hoped to evolve pure grazing areas, studded with shelter trees, capable of supporting a much larger number of cattle than at present.

In this way it is expected to achieve the objects aimed at, that is to say, the reduction in the number of "drone" cattle by limiting the incidence of grazing and raising the fees so that the best cattle get the preference, and the provision of a sufficiency of fodder for the necessary cattle. Incidentally, it will secure to Government a financial return more in keeping with the benefits provided and lead to the improvement both of the pasturage and the yield in wood, all of which is in consonance with the motto ot the Forest Department: *Meliora Speramus*.

SOME OBSERVATIONS ABOUT THE SOILS OF THE NORTH-EAST INDIAN TEA DISTRICTS.

BY

G. D. HOPE, PH.D., B.Sc, F.C.S.,

Chief Scientific Officer, Indian Tea Association.

THE tea districts of North-East India comprise four large and distinct tracts of country. These are, firstly, the Brahmaputra Valley from Sadiya as far south-west as Gauhati; secondly, the valley of the river Surma which is a tributary of the Brahmaputra; thirdly, two tracts of country west of Assam, bounded by the Himalayas on the north and lying due north of Calcutta, known as the Dooars and Darjeeling Terai respectively; and, lastly, the mountainous tea district of Darjeeling proper.

The Brahmaputra Valley contains about 250,000 acres of tea. It is bounded on the north by the Himalayas, on the south and south-east by the Naga, Manipuri, Lushai, and Chittagong hills, and on the west by the hilly district between these hills and Shillong, and north of the Brahmaputra, by the district of Goalpara. The valley is widest at the north-east end, where there is a large level area, the greater part of which lies on the south bank of the Brahmaputra. The valley becomes narrower further south-west until, finally, at the western boundary of the tea-growing districts, the Jaintia and Khasi hills jut out northwards as far as Gauhati from the line of the Naga, Manipuri, Lushai, and Chittagong hills which stretch from Dibrugarh to Chittagong. The Jaintia and Khasi hills cut off the tea districts of Assam proper from those of the Surma Valley, for there is no tea grown on these hills. On the north bank of the Brahmaputra no tea is grown in the Goalpara District, which

is immediately west of Mangaldai which lies north of Gauhati, and it is not until one reaches the Dooars that tea is seen again. No tea to speak of is grown in the Goalpara District for what reason I do not know; but there is no doubt that with drainage this tract would be quite suitable for tea cultivation.

The Assam Valley, the boundaries of which I have just defined, consists of level land sloping down very gradually from the hills on both sides of the valley to the Brahmaputra. In most parts of the valley the land, which is above rice field level, supports either heavy jungle, or tea, or grazing and village sites, and this land is intersected by very characteristic depressions, a few feet deep only, which are known as *hullahs*. These *hullahs* are the natural surface waterways and they run into each other, and eventually on leaving the higher ground open into large tracts of rice fields which are usually only a few feet lower than the surrounding land. These *hullahs* gradually become larger, owing partly to the denuding movement of water from the higher land, and partly to artificial broadening as they are cultivated for the growth of rice.

Near the Brahmaputra, on both sides of the valley, there are large tracts of more recent sandy alluvium which are at present covered with grass. Most of the tea in the valley has been planted on what was originally land which supported heavy jungle, but large areas of this grass land have recently been put under tea. The characteristic feature of the Assam Valley is the general levelness of the land right up to the foot of the hills, and variations of level are confined to a few feet only, except where existing rivers cut through the alluvium on their way to the Brahmaputra. No tea is grown on the hills which border the valley on either side.

In Cachar and Sylhet occur the tea districts of the Surma Valley and its tributaries, in which there are some 150,000 acres of tea. This district has several features not seen in the valley of the Brahmaputra. One is the more generally undulating nature of the land, the extreme limits of these undulations being the *tilas* or small, steeped, round-topped hills that abound all through the district. The second is that, in addition to level or slightly undulating land, there exist plateaux or banks raised by many feet above the general

rice field level. These banks are particularly noticeable at the foot of the Jaintia hills in Cachar. A third noticeable feature is the occurrence of *bheels* or areas between *tilas* filled with peat many feet thick. These *bheel* soils when drained yield remarkably fine crops of tea, and the soils have particular properties which I will deal with later.

In the Dooars and the Darjeeling Terai, where, if we include that grown in the district of Darjeeling proper, there are about 170,000 acres of tea, the land slopes steeply from the Darjeeling and Bhutan hills, and in some places in the Dooars consists of a number of banks. Those which are found nearest to the hills are usually of a red, stiff loam with a deep gravelly subsoil, and are many feet in thickness. These banks are apparently absent in the Darjeeling Terai. South of these banks, or, if these banks are not present, immediately at the foot of the hills, a recent alluvial soil slopes steeply at first, and then with a diminishing gradient towards the plains. Torrential rivers break through the country at intervals along the foot of the hills, and these bring down alluvium which in many cases forms tracts of soil which differ very considerably among themselves and many of which are of special types. In this district, the rice-growing level is well to the south of the bulk of the tea-growing area, and the tea-growing area itself is made up of forest land, grazing land, and, lastly, to no small extent, of dried up or abandoned river beds, useless for agriculture. In the Dooars and the Darjeeling Terai districts, as the actual foot of the Himalayas is approached, the land rises steeply, attaining a maximum height of about 1,500 feet at the foot of the hills.

In the Darjeeling District we have the only instance in North-East India of tea estates being planted entirely on steeply sloping ground. Ghoom, near the summit of the central mountain of the district, rises to a height of 8,000 feet, and from it spurs run downwards in several directions towards the plains or towards deeply cut valleys. The flanks and faces of these spurs are very steep, and tea is planted in many places on gradients as great as 45 per cent. There is no level land at all in the district.

I think this is sufficient to explain the positions and main characteristics of the different tea districts of North-East India. The actual sites of tea estates within each of these areas have been very largely accidental and a matter of occasion. The earliest tea planters in India believed that tea should be grown on or near hills, and consequently, after tea had been discovered growing wild in Assam, the earliest experiments in putting out tea estates were made on hills or near them. Rivers were then the only means of communication. The oldest estates are found at the foot of the hills near the larger and more navigable tributaries of the Brahmaputra, though some small estates were established at a very early date at Gauhati, the only place where the hills approach the Brahmaputra.

I now turn to a more detailed account of the soils of the different districts.

In the first place, it is noticeable that, with the exception of the Darjeeling District itself, the soil of the whole of the North-East Indian tea districts is alluvial in character. The nature of the alluvium has been determined, of course, largely by the geological formations from which its material has been derived, and largely also by the conditions under which it has been deposited. I will deal first with Assam Valley.

The geological formation of the hills immediately bordering the valley on both the north and south banks of the Brahmaputra is a tertiary fluviatile sandstone, and the bulk of the alluvium of the valley has undoubtedly been derived from it. But it appears that there is an old alluvium which crops out from the newer alluvium in places, and this may be derived partly from other formations. Traces of this older alluvium are seen along the foot of the hills on the north bank, and on a tract of land covered by tea north of Tezpore. The same formation will be referred to more particularly when discussing the soils of the Dooars. The alluvium derived from this tertiary sandstone, while differing considerably from place to place according to the nature of its deposition, is yet remarkable for several distinguishing characteristics, chief among which is the invariably high percentage of fine sand, and its even composition

to a great depth and over extensive areas. It is by no means a rich alluvium chemically as one would expect of a soil, in the first place, derived from sandstone; and, secondly, constantly subjected to the leaching action of rain, as is the case in Assam, where there is a high rainfall. The Assam alluvium is particularly poor in organic matter—nitrogen, phosphoric acid, and lime—but it is a soil which is naturally pervious to water, and, if the necessary run-off can be obtained and the soil is adequately drained, it affords a very fine medium for the growth of tea plants. It is sufficiently retentive of water to satisfy the requirements of the plants in the dry season, and it is easy to cultivate and maintain in a condition of good tilth.

A special study of this alluvium has been made in the neighbourhood of the Tocklai Experimental Station, our headquarters in Assam, and four definite sub-types are found to constitute the bulk of the soils of the district. In all of these, fine sand is the chief ingredient, and there is a definite gradation in quantity from fine sand through silt, and fine silt, to clay, while the amount of coarse sand varies, and this variation is chiefly responsible for the difference in type. Though this district is one in which this evenness of character is marked, other districts also which are bordered by the tertiary sandstone afford numerous examples of entirely similar soils. On the north bank of the Brahmaputra a complication arises owing to the flooding which often takes place from the rapidly moving rivers which come down through the Himalayas carrying silt derived from rocks of other kind than sandstones, and it is only owing to the fact that the rivers on the south bank carry less silt and are usually less violent than those on the north bank that this complication arises to a lesser degree in the case of the soils to the south of the Brahmaputra.

Wherever the hills bordering the plains consist of rock other than sandstone, a difference in the type of soil is immediately noticeable. A tract of country which shows this clearly is that which lies between Sibsagar and Jaipur, where the alluvium of the valley is in immediate contact with shaley and slatey rocks of the Desang series. Here some of the heaviest tea soils of the Assam Valley are

situated, and a definite characteristic of the soils of this tract is the almost complete absence of coarse sand. The Nowgong District in Lower Assam contains also some very heavy soils which are derived chiefly from the Mikir hills which contain gneiss and other metamorphic rocks similar to those found in the Himalayas.

The fluviatile sandstone formation, which extends along the edge of the hills on the north and south of the Brahmaputra Valley, extends also almost uninterruptedly in a direct line towards Chittagong, and consequently the more level land surrounding the older of the low hills, or *tilas* as they are called, consists of soil very similar to that of the general sandy alluvium of Assam. The soils of the older *tilas* themselves are usually stiffer and have indications which point to their greater age. Also in the north of this district, at the foot of the hills which separate it from Assam proper, there exists a bank of heavy red soil akin to the red soils I have spoken of as occasionally cropping out in Assam and the Dooars.

The most interesting feature of this district, however, is the existence of pockets or *cul-de-sacs* of peat soil of very remarkable depth and composition. The reason for the existence of such soils in the Cachar and Sylhet districts, and practically nowhere else, lies, I think, in the position and direction of the ranges of hills that separate the different tea-growing valleys, in relation to the line of flow of water towards the Surma and the other bigger waterways. These hills usually lie directly across the natural lines of flow of water, and consequently water backs up and collects to a much greater extent here than in Assam and in the Dooars. This, I think, accounts for the formation of peat. A hollow between two small hills is blocked at one end and water cannot find an outlet, and gradually after many years a layer, sometimes as much as 20 feet thick, of peat, or *bheel* as it is called, is formed. When such a *bheel* is first opened out with the object of planting tea, an outlet is made for the water, and a big drain, perhaps 10 or 12 feet in section, is cut, and the *bheel* is drained for the greater part of a year. When tea is planted on such soil it grows remarkably rapidly and gives a very big crop of tea per acre, which, however, is of poor quality. Ultimately, after 15 or 20 years, the *bheel* sinks

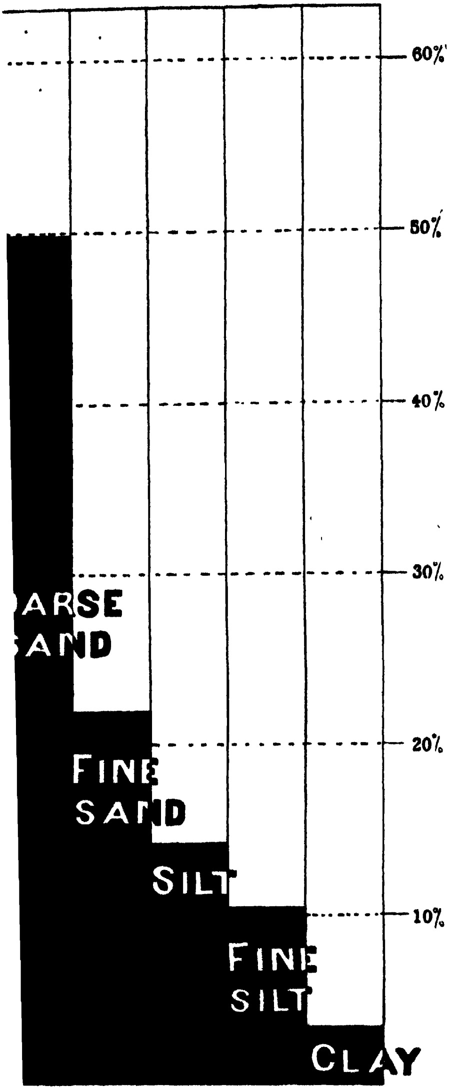
by many feet, and in most cases the tea bushes then deteriorate very rapidly, though even at that stage the ultimate composition of the soil as regards percentages of total nitrogen, potash, phosphoric acid, organic matter, etc., resembles that of a very rich dung.

In the Dooars there is a broken line of tertiary sandstone along the foot of the Himalayas, but since the rivers break through this, and through the older rocks beyond it, with great violence, a very large part of the soil immediately at the foot of the hills is obviously derived from other formations.

A very much larger part of the Dooars tea districts, relatively to that of the others, is made up of the old red soils known as the Red Bank. This soil is of great depth and is characterized by being comparatively rich in coarse sand and clay, and poor in fine sand, silt, and fine silt. It is a loam, though a heavy loam, rather than a silt soil, and is capable of assuming a very fine tilth if well cultivated. These red soils are usually acid, contain very little lime, and are rather deficient in phosphoric acid, and citric acid soluble phosphoric acid is low. A very important feature of these soils is the fact that the ratio of clay to fine silt is usually high, which fact, taken with others, indicates, I think, that the soil has been *in situ* long enough to have weathered considerably.

The next most characteristic soil of the Dooars is one which, with the Red Bank soils, makes up the greater part of the whole area. This type of soil is known as the grey sandy loam, though in many cases it might be more accurately described as the grey sandy silt. Soils of very different types and ages are found among it, and are classified together more for convenience than for any other reason, for the only common feature they possess is that they have been deposited much later than the Red Bank soil. However, we can pick out some interesting sub-types, one of which is particularly interesting in connection with the most serious pest which occurs on tea estates, an insect known as *Helopeltis theivora*, commonly called the Tea Mosquito. This pest is particularly prevalent on soils of the type I am about to describe. These soils have been deposited from the rivers which come down from the Himalayas,

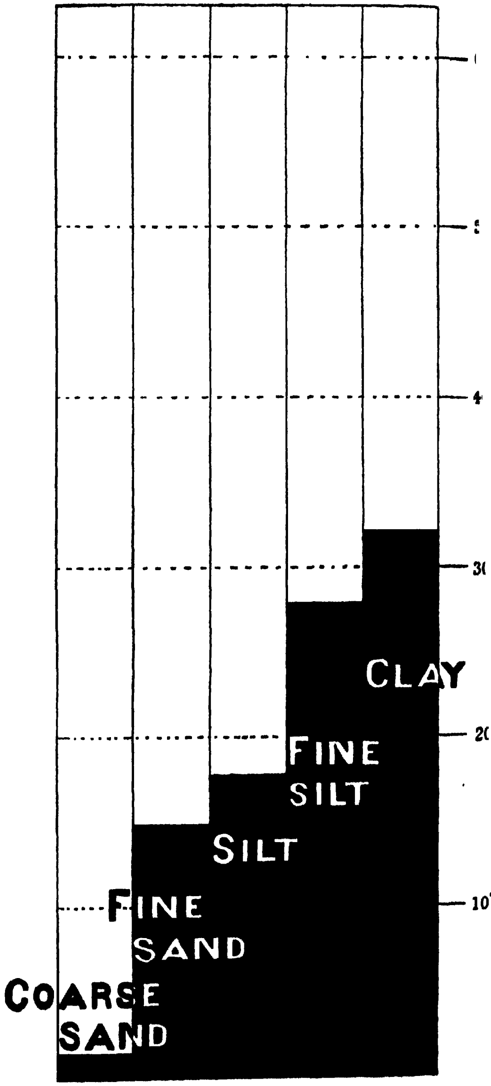
DIAGRAM I.



Scale 9′=1 inch.

ıarigoomia Tea Estate, soil marked No. C.

DIAGRAM II.



Scale 9′=1 inch.

Moheema Tea Estate, soil marked Moheema C Top.

and they consist of coarse or fine quartz sand accompanied by a large percentage of talc and potash mica. They possess fairly high percentages of phosphoric acid and remarkably high figures for citric acid soluble phosphoric acid. They are rich in potash and, curiously enough, the percentage of citric acid soluble potash is usually low, and is often present in traces only. These soils afford therefore the best illustration of an interesting fact which we have ascertained in connection with the attacks of the tea pest I have just mentioned, namely, that in a given district so small that the climatic factor may be considered uniform throughout, the attacks of the pest are less intense in the cases of estates where the ratio of citric acid soluble potash to citric acid soluble phosphoric acid is high, than in the case of estates which have soils in which the ratio is low.

Other soils belonging to the grey sandy class are actual silts, and they have large percentages of talc and other minerals which contain magnesia. Other purely sandy and still other clayey silt soils occur as sub-types.

In addition to this class of soil and the Red Bank soils there are a few others of rather special character. One particularly, derived from a carbonaceous shale, is very heavy and black in colour. The soil when damp reminds one of boot blacking. It has proved to be most unsuitable for tea.

In the Terai there is no very distinctive outcrop of the Red Bank soils, and the soils throughout are chiefly coarse and sandy, though they are stiffer further away from the hills than close under them.

Having thus described the main features of the soils of these districts, I would like, in conclusion, to draw attention to a few special problems which are at present engaging our attention. We are making a survey of these soils, based on mechanical analyses, by a method similar to that of Hall, and I have here a few diagrams showing some of the analyses we have made. A coarse alluvial soil deposited from running water is represented by Diagram I, while a clay soil, deposited by the gradual settling of sediment after the water which brought the sediment has ceased to flow,

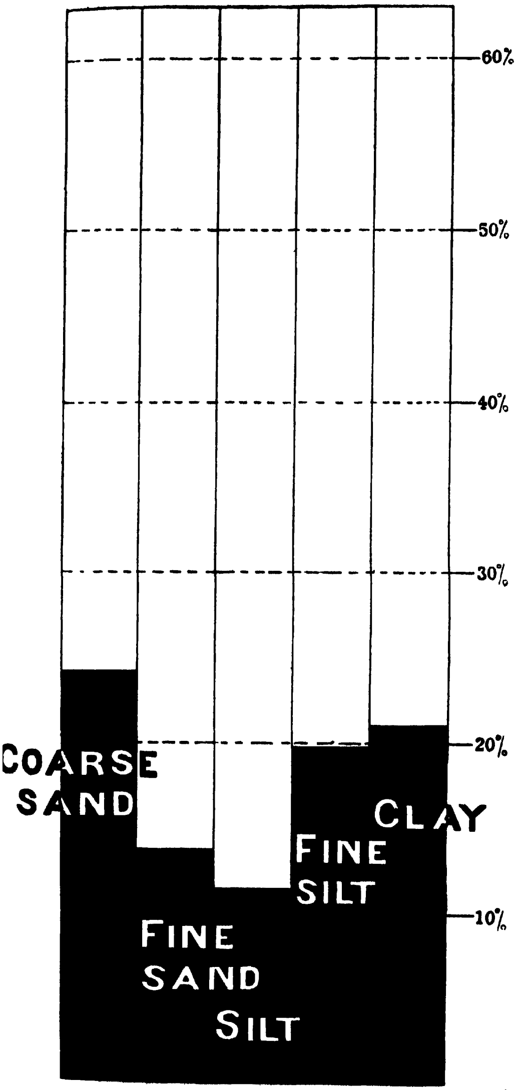
is represented by Diagram II. Assuming that a coarse sandy soil, similar to that represented by Diagram I, is deposited, then, if the fragments of which it is composed consist of decomposable silicates as well as of quartz fragments, in process of time that part of the fine silt which consisted of decomposable silicates would be further decomposed into clay, and some of the silt into fine silt, and so on, with the result that the soil would eventually have a mechanical analysis such as that represented by Diagram III. If indications point to the soil having been originally deposited in such a way as to have a mechanical analysis grading off definitely and regularly from one direction to the other, as one would expect in an alluvial soil deposited from water, I think there is some justification for accepting an upward rise in the curves as an indication of weathering having taken place since the soil was deposited.

In the case of the soils of the Assam Valley, coarse sand seems to have been very largely eliminated when the tertiary sandstone which borders the valley was formed, and consequently the coarser soils have usually fine sand, and not coarse sand, as their chief constituent. A typical soil formed from the tertiary sandstone is given in Diagram IV. We have here to remember that a twofold deposition has taken place—(*a*) that which gave rise to the material from which the sandstone was formed, and (*b*) that which took place when the sandstone was broken down to form alluvium.

It seems probable that when a large collection of mechanical analyses have been made and studied in this way in connection with the chemical nature of the minerals composing the soil, and with the geological characteristics of the tract of rock from which these soils are likely to have come, we shall be in a better position to understand exactly how these soils have been deposited.

Another very interesting problem is in connection with the red soils of the valley. There appears to be a definite connection between the red colour of the soil and the value of the ratio of fine silt and clay. On the loamy Red Bank soils the ratio of clay to fine silt is usually higher than unity, and this, as mentioned above, presumably indicates greater age. The behaviour of the Red Bank

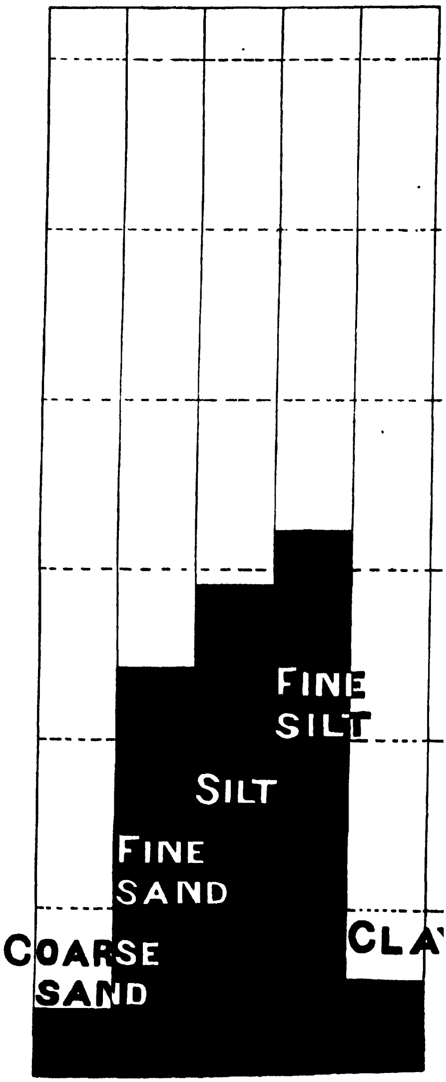
DIAGRAM III.



Scale 9' = 1 inch.

Chaloni Tea Estate, soil marked 9 Surface Soil.

DIAGRAM IV.



Scale 9' = 1 inch.

Rota Tea Estate, soil marked No. 10.

soils is quite different from that of other and newer soils with similar mechanical analyses, for, with reasonable cultivation, they are capable of assuming a much more excellent tilth than could be acquired by clay soils of the same mechanical composition.

A few years ago I spent some weeks in Java and was much interested in the lateritic soils that are found on the island, particularly at lower elevations. The composition of lateritic soils is there explained on the assumption that the climate alone is responsible for their formation, and the climate which brings this about most quickly and completely is one with a high rainfall distributed so that the movement of water in the soil is usually downwards, and one where the temperature is high. The geographical distribution of laterite in many parts of the world agrees fairly well with this assumption.

Now I am inclined to think that, either owing to the climate of Assam having changed and having once been wetter and hotter than it is now, or to the very long period during which these soils have been weathering in a climate which approximates to, though it does not entirely satisfy, the conditions of a climate in which laterite would be formed, these old soils have taken on a partially lateritic character, that is to say, they have broken down in weathering beyond the clay stage and contain considerable quantities of hydrated oxide of iron and alumina. I have made some experiments to determine the extent to which this has taken place in the red soils of the tea districts. The method adopted has been to determine the extent to which iron and alumina hydroxide are extracted from these and from other soils by different strengths of acid. So far as my experiments have gone (they have been conducted with samples of soil taken from 5 feet below ground in order to avoid as far as possible complication due to the presence in the soil of large quantities of organic matter) it appears that in cold hydrochloric acid of different strengths the total iron oxide and alumina removed is considerably greater than in the case of pure clay soils, but I have so far been unable to obtain any ratio of solubilities in dilute and strong acid which would enable one to pick out a lateritic from a clayey soil.

I would welcome any suggestions as to how further to investigate this problem. I start out from the definite agricultural difference which exists between the two types of soil—one red and the other grey—both having exactly similar mechanical analyses, but the red one having a very much greater possible range of tilth, and being therefore capable of behaving very much better in the field. I put down this difference between the two types of soil to the difference in behaviour of the colloidal substances in them.

There is another interesting problem in connection with the deterioration of *bheel* soils. In some cases the lack of fertility which comes after a few years in the case of soils of this class, which are still enormously rich, appears to be due to the formation of a wax which coats the particles of soil and prevents them getting wet. In other cases it is probably due to some condition affecting bacterial activities in the soil, but this I have at present made no attempt to investigate.

Finally, not to weary you with more than one other of the many problems that lie before us in connection with the tea soil of North-East India, there are certain grey sandy soils as the Dooars which contain a very high percentage of magnesia relative to lime, the ratio being in some cases as high as 14, that is to say, there are 14 times as much total magnesia as lime in the soil. In no case, however, is the ratio of citric acid soluble magnesia to citric acid soluble lime of this order, though it is sometimes as high as 2 or 3. This points to the well-known fact that magnesia has a greater tendency to combine in the form of silicates in the soil than lime has. There appear to be certain soils which have such high ratios of magnesia to lime that they are unsuitable for the growth of tea. This is a problem which I should like to investigate more carefully on the lines of investigations which have been made elsewhere as to the value of this ratio on the growth and health of other plants.

In conclusion, I hope I have succeeded in showing you that in the tea districts of North-East India we have a by no means uninteresting collection of soil types—a collection which it will well repay us to study in connection with cultivation, drainage, manuring, and other problems.

I am much impressed, and I have emphasized its importance elsewhere, with the necessity of all agricultural officers and others who are studying soil problems in India making themselves acquainted with what others are doing in the field of enquiry, and I welcome any occasion when there can be exchange of opinion and of experience.

FOREST INSECT CONDITIONS IN INDIA.

BY

C. F. C. BEESON, M.A.,

Forest Zoologist, Forest Research Institute, Dehra Dun.

SINCE the establishment of forest research on organized lines in 1906, the work of the branch of Forest Zoology has been confined to the collection of information on the life-histories and economics of the insect pests of a few of the more valuable timber trees, and so far little attention has been paid to the question of control measures. The need for the early introduction of systematic methods for the control of the more important species has been recognized, but in Indian forests the necessity is far less urgent than that existing in other countries where systematic forestry is practised.

The insect pests of forests may be roughly grouped under three heads :—

(1) Insects which kill trees.
(2) Insects which cause loss of increment without causing death.
(3) Insects which cause technical damage to timber and forest products.

Insects of group (3), technically injurious species, are to be found wherever tree growth exists, but insects of groups (1) and (2), physiologically injurious species, are distributed with less uniformity throughout the forest tracts of the world.

The object of this paper is to attempt a comparison of the primary pests of Indian forests, *i.e.*, defoliators, bark-beetles, and heart-wood borers, with the known primary pests of other countries, but as a result of lack of data one is restricted to a consideration

of forest insect conditions in the temperate regions of Europe and North America.

I. Central Europe.

The early development of systematic methods of forest management in the countries of Central Europe and in particular in Germany established at an early date rational lines of study of forest insects as a branch of applied entomology. Forest entomology may be said to have been created in Germany a century ago by Ratzburg and his co-workers Hartig and Nördlinger.

The insect pests of European forest trees have thus been under observation sufficiently long to furnish definite conclusions as to the types of insect damage that are normal in virgin forests on the one hand, and in forests under systematic management on the other.

The principal primary pests of Central Europe are mainly pests of coniferous forests. As is to be expected, evergreen conifers suffer far more from insect injury and especially defoliation, than do hardwoods which renew their foliage yearly and exhibit in general far greater recuperative powers.

The Nun Moth, *Liparis* (*Lymantria*) *monacha*, L., fam. Liparidæ, is a polyphagous defoliator of conifers and hardwoods. Nun Moth epidemics last generally for 5—7 years and are accompanied by the total destruction of spruce and pine forests over wide areas. The more important epidemics of the last century occurred in 1835-40 in North Germany, in 1845-67 in Prussia and West Russia, in 1889-92 in South Germany, in 1898-1901 in Sweden and Germany, and in 1905-11 in Austria, Saxony, and Prussia.

Dendrolimus pini, L., fam. Lasiocampidæ, is the most importtant primary enemy of the pine (*Pinus sylvestris*) ; in an outbreak, which lasted from 1862-72, some 4,000 square miles in Russia and North Germany were affected.

The Pine Looper, *Bupalus pinaria*, L., fam. Geometridæ, and the Pine Beauty, *Panolis griseovariegata*, Goetze., fam. Noctuidæ, are other dangerous defoliators of pine woods. The last looper epidemic in 1892-96 resulted in the clear felling of over 150 square miles of pine forest in Bavaria.

Fatal defoliation of beech and oak and other hardwood forests is due to outbreaks of the Gypsy Moth, *Porthetria dispar*, L., the Gold-tail and Brown-tail Moths, *Euproctis* (*Actornis*) *Chrysorrhœa*, L., and *Nygmia phœorrhœa*, Don., fam. Liparidæ.

Borers. Of bark-beetles the most important primary pest of coniferous forests is *Ips typographus*, L., fam. Scolytidæ; *e.g.*, in 1781-83 this species killed off 2½ million spruce in the Harz mountains. Severe epidemics occurred in 1862 in East Prussia and in 1868-70 in Bohemia ; in the latter outbreak 400 square miles of pine forests were devastated. In 1902 some 150,000 spruce and silverfir were killed off in the Vosges mountains.

In Europe where natural regeneration of the forest is permitted only in accordance with silvicultural rules, or else regeneration is entirely artificial, one finds that young growth is subject to the attack of primary insects. Sowings, plantations, and natural regeneration areas of spruce, pine, and fir are fatally injured by weevils, *e.g.*, *Hylobius abietis*, L., and *Hylobius* spp., fam. Curculionidæ ; conifers and hardwoods by cockchafer grubs and beetles, *e.g.*, *Melolontha vulgaris*, L., and *M. hippocastani*, F., fam. Scarabæidæ.

UNITED STATES OF AMERICA.

Although forest entomology is at present the least developed branch of applied entomology in the United States, yet it has shown that the very serious losses which North American forests suffer from the depredations of primary pests are controllable by simple non-expensive methods. The average annual loss due to insect damage is estimated at over £12,000,000 which is upwards of £2,500,000 annually in excess of the average yearly loss due to fires.

Defoliators. The primary pests do not include many species of defoliators. The most injurious appears to be the Large Larch Sawfly, *Nematus erichsonii*, Hartig, fam. Tenthredinidæ, which, during several extensive outbreaks since 1880, has killed off from 50 to 100 per cent. of the mature larch over vast areas in the North-eastern United States.

The defoliator of greatest local importance is the Gypsy Moth, which, introduced from Europe to the States in 1868, is now widely

spread throughout eastern New England, defoliating forest, shade, and fruit trees, and agricultural crops, and entailing enormous losses and the expenditure of millions of dollars in control work. In recent years it has become established in forest areas, defoliating especially oaks, aspen, poplar, beech, limes, birch, and pines.

Bark-beetles. North American coniferous forests suffer from extensive invasions of various species of bark-beetles of the genus *Dendroctonus*, fam. Scolytidæ.

In 1890-92 the Southern Pine Beetle, *Dendroctonus frontalis*, Zimm., killed off a large proportion of spruce and pine over 75,000 square miles in West Virginia, Maryland, and Columbia. The Eastern Spruce Beetle, *D. piceaperda*, Hopk., killed off mature spruce over thousands of square miles in the forests of North-eastern Maine.

The Black Hills Beetle, *D. ponderosæ*, Hopk., has killed off in a ten-year period about a hundred million cubic feet of western pine in the Black Hills National Forest of South Dakota. The sugar pine, silver pine, western yellow pine, and lodge pole pine of the region north of Colorado and Utah, are attacked by the Mountain Pine Beetle, *D. monticola*, Hopk., and the Western Pine Beetle, *D. brevicomis*, Lec., and in direct consequence millions of feet of timber have died. In one locality in Oregon 90-95 per cent. of the lodge pole pine on an area of 150 square miles was killed off in three years. The Douglas fir throughout the region of the Rocky Mountains suffer very severely from the ravages of the Douglas Fir Beetle, *D. psendotsugæ*, Hopk.

The Hickory Bark-beetle, *Scolytus quadrispinosus*, Say., has caused the destruction of an enormous amount of hickory timber throughout the Northern and Eastern States

The hardwoods, *e.g.*, oaks, chestnut, beech, elm, etc., suffer far less from the work of primary pests, but are subject to the attacks of secondary heart-wood borers such as the timber worms, *Eupsalis minuta*, Dru., and *Lymexylon sericeum*, Harr., the carpenter worms of the genus *Prionoxystus*, and ambrosia beetles, shothole borers, and turpentine borers

CANADA.

The forests of Canada, covering an area of one and one quarter million square miles of which about 400,000 square miles contain merchantable timber, are composed chiefly of conifers. Outbreaks of primarily injurious insects occur in virgin forest on a large scale, and the need for investigation was recognized by the appointment of a forest entomologist in 1911.

Defoliators. Of the defoliators the most important pests are the Large Larch Sawfly, *Nematus erichsonii*, Hartig, fam. Tenthredinidæ, the Spruce Bud Worm, *Tortrix fumiferana*, Clem., fam. Tortricidæ, the Brown-tail Moth, and the Pine Butterfly, *Neophasia menapia*, Felder.

The Large Larch Sawfly during the last 20 or 30 years has shown itself to be a serious pest of the larch (*Larix americana* and *Larix* spp.). In 1881-86 it killed off by repeated defoliation practically all the mature larch in Eastern Canada : outbreaks occurred again in 1894-98 and 1903-06. Considerable damage has been inflicted by the Spruce Bud Worm to the balsam and the spruce, especially in the eastern regions of Canada, and to the Douglas fir (*Pseudotsuga douglasii*) in Vancouver Island.

Canadian forests of both coniferous and broad-leafed species (oak, elm, and maple) are threatened also by the Brown-tail Moth, which appeared 12 or 15 years ago and is now endemic in the transition zone of Nova Scotia, and epidemic in the boreal parts of New Brunswick. There is every possibility, if the insect becomes established, of its being a serious pest throughout the transition zone of the Dominion.

Borers. The destruction caused by defoliators is slight compared with that due to the depredations of bark-beetles of the genus *Dendroctonus*. What has been said about these species in the Rocky Mountains and the Pacific Coast region of the United States holds for corresponding regions in Canada. The tree species suffering most seriously are *Pinus ponderosa*, *P. monticola*, *P. murrayana*, *Pseudotsuga mucronata*, and *Picea sitkensis*.

It must, however, be noted that the three most injurious defoliators of North America and Canada are not indigenous species but introductions from Europe.

II. British India.

There are 250,000 square miles of forest in India and Burma, of which 108,000 square miles are under more or less systematic management, but in at least half of this area we have little idea of the rôle played by insect pests or even if economically important pests exist. Although some 55,000 square miles of forests are managed under Working Plans at the present time, we have not as yet brought into force methods to ensure the systematic record of damage due to insect pests, nor are we able to calculate the value of the annual loss due to any one species. The data available, however, show, even in a rough comparison, that well-marked differences occur between forest insect conditions in India and those in other parts of the world.

Defoliators. Of defoliators in coniferous forests India appears to have no species that correspond to the sawfly and lasiocampid caterpillars of North America and Europe. The Himalayan pines, silver firs, spruce and deodar, and the evergreen oaks of the mountain forests are (so far as any records are available) entirely free from primary defoliation with fatal results.

Of the hardwoods several species of lepidopterous defoliators are known and widespread. In deciduous forests the teak, *Tectona grandis*, is defoliated periodically, and frequently annually, throughout the whole of its distribution by two species, *Hyblæa puera*, Wlk., fam. Noctuidæ, and *Pyrausta machæralis*, Cram., fam. Pyralidæ, and several species of Arctiidæ, but no case of fatal defoliation sufficiently extensive or prolonged has been recorded which would cause these species to be considered as primarily injurious insects. Complete defoliation of teak is followed by a rapid renewal of the crown foliage or by temporary production of epicormic shoots. The injury is thus restricted to loss of increment and occasional stagnation.

The sal, *Shorea robusta*, is defoliated by numerous species of Lepidoptera most of which appear in groups or associations, *e.g.*, *Dasychira thwaitesi*, *D. horsfieldi*, *D. mendosa*, *Lymantria ampla*, *L. bivittata*, *L. semicincta* which defoliate hundreds of square miles of sal forest in the eastern parts of its range. The earliest record refers to an attack in 1884 in which 200 square miles of forest north of the Brahmaputra river were completely defoliated. *Trabala vishnu*, Lef., *Suana concolor*, Wlk., fam. Lasiocampidæ, *Ingura subapicalis*, Wlk., fam. Noctuidæ, and other species periodically defoliate the tree in the Central Provinces and in the United Provinces.

Almost every timber species of importance in the deciduous and evergreen forests supports a series of lepidopterous and coleopterous defoliators and pruners, nevertheless in the above-quoted instances, and in the arid-country and littoral forests where pests have been less extensively studied, there is a complete absence of epidemics which have resulted fatally to the forest as a whole or to all the individuals of one tree species in the forest.

Borers. The Himalayan conifers are attacked by species of bark-beetles generically allied to those of the European and American conifers, *viz.*, *Ips*, *Polygraphus*, *Cryphalus*, *Scolytus*. *Ips longifolia*, Steb., is the most destructive pine bark-beetle throughout the zone of *Pinus longifolia* and *Pinus excelsa*. The deodar (*Cedrus deodara*) is attacked by species of *Scolytus*, a genus which is confined to broad-leafed trees in European and American forests. Under normal conditions the bark-beetles are not primary pests, but a few instances occur in which appreciably large areas of forest have been devastated by epidemic outbreaks, *e.g.*, in 1903-06 in the forests of *Pinus gerardiana* in Baluchistan by *Polygraphus trenchi*, Steb.; in 1908-10 in deodar forests in the Simla Catchment Area by *Scolytus major*, Steb.; and in *Pinus longifolia* forests in the United Provinces in regeneration areas and following on serious fires by *Ips longifolia*, Steb. The case of primary outbreaks of *Ips longifolia* in regeneration areas of chir pine is a habit of recent development and hardly to be considered as normal, as it is associated with the changes in forest management which favour the concentration of regeneration

operations and consequently of breeding grounds for the insect. Other apparently primary activities of the Pine Bark Beetle in plantations have recently been shown to be consequent on previous attack by bark blister fungi. Bark-beetles of timber species in deciduous and evergreen forests are, in all observed cases, undoubtedly of secondary origin. The species of *Sphærotrypes* and other bark-beetles which breed in *Anogeissus latifolia, Terminalia tomentosa, Shorea robusta*, and other *Dipterocarps* do not successfully attack living healthy trees.

Shothole and pinhole borers, fam. Scolytidæ and Platypodidæ, represent a class of borers which are characteristic of Indian forests, as also of most tropical and semi-tropical forests, and which are comparatively absent from European and North American forests. Conifers and oaks in the mountain forests and practically every timber species of economic importance in the deciduous and evergreen forests are subject to attack by shothole and pinhole borers. The sal, for example, serves as breeding material for at least 27 species of *Xyleborus*, *Progenius*, *Diapus*, *Platypus*, *Crossotarsus*, etc. As far as the writer's observations go they are all to be classed as pests of secondary importance; the technical damage done is very considerable, but the attack is confined to dying and unhealthy trees. In 1911-14 considerable mortality in the sal forests of Bengal was assigned to *Diapus furtivus*, Samps., fam. Platypodidæ, until investigation showed that the species was present in only 16 per cent. of the dead trees, and that the shothole borer attack was secondary to that of a root parasite, *Polyporus shoreæ*. Again in the Sunderbans forests of Sundri, *Heritiera Fomes*, an epidemic outbreak of *Crossotarsus squamulatus*, Chap., fam. Platypodidæ, which occurred with all the appearances of a primary outbreak, was found to be limited to trees possessing diseased roots. Heart-wood borers of the families of Cerambycidæ and Lamiidæ (Coleoptera), and Cossidæ and Hepialidæ (Lepidoptera) are common pests of the more important trees, but it is doubtful if any are normally capable of killing off forests over large areas. The teak during the first few years of its life is attacked by a lamiid, *Haplohammus cervinus*, Hope, and the hepialid *Phassus*

malabaricus, Hmps., which produce cankerous and distorted growth in young saplings with galleries in the heart-wood. Young *babul* (*Acacia arabica*) is attacked by a lamiid, *Cœlosterna scabrator*, F., while numerous other trees now grown in plantations show similar attacks in the sapling stage. In plantations of these trees repeated attacks are often serious enough to cause the death or stagnation of a large proportion of the crop, but under natural conditions the activities of the pest have never been sufficiently conspicuous to cause comment.

The sal is not attacked by heart-wood borers in its youth but trees over 2 feet in girth suffer serious technical damage from the larvæ of *Hoplocerambyx spinicornis*, Newm., fam. Cerambycidæ. Normally this species breeds in dying or diseased trees. Under abnormal circumstances it may assume the character of a primary pest, but its rate of increase and dispersion is so slow that it can be easily controlled. In those Bengal and Assam sal forests where a generally unhealthy condition of the soil prevails, the proportion of dead trees infested by *Hoplocerambyx* has not exceeded 40 per cent. in an observed period of three years, although the borer is endemic in the area. In a recent local outbreak of this species in United Provinces sal forests the number of living trees infested in the sixth year of the attack is less than 30 per cent. of the whole crop, and the area affected under 2,000 acres.

The teak is attacked from the young pole stage to the end of its life by a serious pest, the beehole borer, *Duomitus ceramicus*, Wlk., fam. Cossidæ. The heart-wood of the living tree may be riddled with galleries an inch in diameter without affecting its vitality; in fact the average teak tree reveals nothing of the activity of the beehole borer until it reaches the saw mill.

Numerous other illustrations might be cited to show the absence in the forests of India of a primary insect pest which is capable of killing off vigorous healthy trees, or of devastating virgin forests over a large area. The principal pests of natural forests are purely of secondary importance, normally breeding in unhealthy or newly killed timber, and incapable of successfully attacking healthy trees. But it should be understood that the

species in question are of secondary importance only in respect to their directly fatal powers. As causative agents of serious technical damage to timber, of loss of increment, of stagnation and malformation, they are admittedly of primary importance, and in this respect undoubtedly stand as high as the secondary pests of other countries.

This condition of inter-relationship between insect species and their hosts would appear to be normal on the one hand in strictly virgin forests, and on the other hand in ravaged forests which under protection are resuming a stable condition approaching the primitive. Conditions outwardly similar prevail, as far as it has been possible to ascertain, in the forests of the Dutch East Indies, the Philippines, East and Central Africa, and the northern coastal belt of Australia.

The past methods of forestry in India have not favoured the development of forest insects to the stage of primary pests. The retention of the normal distribution and proportion of tree species in the growing stock prohibits extraordinary increase of defoliators, while the methods of timber felling and extraction do not provide facilities for abnormal breeding of borers.

As the majority of the forests now worked in India are irregularly stocked as regards species and age classes, and felling operations are carried out by the selection of small numbers of trees over large areas—a method which reproduces natural conditions more exactly than other silvicultural methods—an abundance in any one locality of loppings, slash and unconverted portions of logs which serve as breeding grounds for borers is avoided. Moreover, extraction of the timber usually takes place within a few months of felling and at a period when the imaginal activity of the pest is lowest.

The objects of forest management in the future, however, do not tend towards the maintenance of the forest in its primitive natural condition but rather towards the elimination of economically worthless species, and the production of more uniformity in distribution and age of the valuable species. In several divisions already Working Plans are in force which are converting the original

irregularly stocked forest into an artificial type of forest consisting of a series of even-aged crops with an increased proportion of the economically valuable species.

In forests of the uniform type fellings and regeneration operations are more concentrated both in time and in place and the danger of abnormal insect activity is thereby increased. It is in these forests and in our artificial regeneration areas and plantations that we may expect in the near future to find the existing secondary pests assuming under epidemic conditions the rôle of primary pests. But at the same time it is in these forests that control measures can be introduced on a scale more practical and efficient than at present possible.

EXPERIMENTS IN PLANTING SUGARCANE SETS WITH A SINGLE EYE-BUD AND POT EXPERIMENTS WITH OTHER SEEDS PLACED IN DIFFERENT POSITIONS WHILE PLANTING.

BY

M. L. KULKARNI,

Acting Deputy Director of Agriculture, Southern Division, Bombay.

THE writer has been carrying out some experiments at the Government farm, Dharwar, on the effect which sowing or planting seed in different positions in the ground has on the subsequent growth of the crop. As the preliminary results are encouraging they are given below :—

Sugarcane. The usual method of planting sugarcane at Dharwar is to plant sets with three or four eye-buds in furrows, with irrigation water given in the furrows before planting. The sets are put in, in rows by hand, and are often trampled under foot, and thus buried in the wet soil. By doing so, the eye-buds are placed in different directions in the ground, some pointing upwards, some on the sides, and some downwards. The buds that are on the top of the sets germinate early, those on the sides later, and those at the bottom die out altogether. Thus the sets produce a smaller number of plants than they are capable of, giving also uneven germination. To avoid the latter, an experiment was conducted on the Dharwar Farm, in small beds in the first year, and on a field scale in the second year (current), of planting sets, cut so as to contain only one eye-bud each, that eye-bud being placed

upwards. The experiments have been successful in both years in the following points :—

(*a*) Sets with a single eye-bud, planted as described above, have given a higher percentage of germination than in the local method of planting. The germination in the single eye-bud method was above eighty per cent.

(*b*) The germination in the case of the single eye-bud method was earlier by one week, and all the plants germinated simultaneously. Thus a uniform crop has been secured.

(*c*) The eye-buds being placed upwards, the plants go straight up, and if planted deep, there is less liability of the cane lodging when grown up, and also there is greater facility for work between the rows, *viz.*, interculture and earthing up, etc.

As there is very high percentage of germination of the eye-buds originally planted by this method, there is no necessity of allowing subsequent tillers to grow into canes. Thus in the single eye-bud method, all the tillers are removed, and only the mother canes are allowed to develop. Hence all the manure given becomes available to the mother canes only, and consequently they develop into long thick canes of uniform age, and ripen all at the same time, by which a higher percentage of sugar is expected than in cases of uneven age at harvest time.

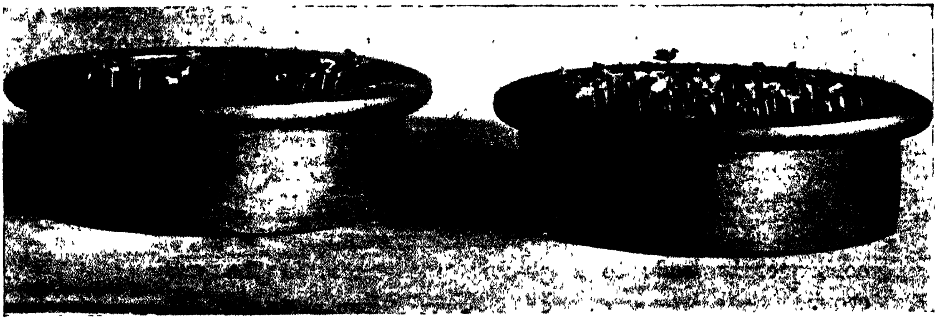
By the method described above, the writer has got above 32,000 canes per acre of good size, the average weight of each cane being about five pounds. The crop is yet standing, and the actual weight of canes cannot be given until it is harvested. A few canes have, however, been weighed, and the weight has been between four and six pounds. Thus it is expected that the yield under the single eye-bud system of plantation would be above 130,000 lb. of cane per acre.

The photographs opposite (Plate VIII) will give an idea of the uniformity of the crop, *viz.*, height and thickness of the canes without any tillers.

Fig. 1. Side view of the sugarcane rows grown with single eye-bud sets.

Fig. 2 Front view of the sugarcane rows grown with single eye-bud sets.

Cotton. Seeds planted with the apex upwards germinated earlier than any others, while those with the apex downwards germinated later, and those with the apex sideways came up last. The great peculiarity in the seeds planted with the apex upwards was that the seed coat entirely remains in the ground, while in the



COTTON.

Apex down plants with seed-caps on the cotyledons.

Apex up plants without any seed-caps on the cotyledons.

two other cases the seed coat is brought up by the plumule. The young plant is hindered in its development by the fact that it has to carry the seed coat up with it through the soil, and it is some time before it gets rid of the encumbrance. The result is that there is a marked difference between the length of time taken by the plants to appear above ground, to allow the cotyledons to open fully, and to acquire a green colour ; the plants from seeds put in with the apex upwards always appearing first and getting a better start.

Cereals. The seeds tried were *jowar* (*Andropogon Sorghum*) and wheat. In these cases, seeds planted with the apex sideways germinated earlier than those in which the apices were placed upwards or downwards. The seeds with apices upwards were earlier than those with the apices downwards.

Leguminous plants. (1) *Sann* (*Crotalaria juncea*) was tried as it was considered to be one of the most quickly germinating seeds we have. In this case the seeds with the apices downwards

germinated first, while those planted with the apices upwards germinated before those planted sideways.

Unlike cotton, the seed coat was brought up by the plumules in all the three methods of planting.

(2) *Gram* (*Cicer arietinum*). In the case of gram the seeds placed sideways and upwards germinated simultaneously and fully earlier by one day than those whose apices were placed downwards.

There are many seeds whose shapes are such that, when sown, they naturally fall in the ground only in certain positions. Among such seeds are wheat, rice, linseed, and *sann*. It may be for this reason that these crops are seen to give, on the average, a much more even stand in the fields than many other crops, such as *jowar*, maize, gram, cotton, *tur* (*Cajanus indicus*), etc., whose rounded shapes make them fall at random in the ground, and consequently leads to a greater unevenness in the subsequent crop.

Similarly, some of our garden crops which are grown by planting sets with the eye-buds upwards, or in any particular direction, are even in growth. The most striking example of these is *suran* (*Amorphophallus campanulatus*). In this case sets of uniform age with uniform eye-buds are planted at a uniform depth with all the eye-buds placed upwards, with the result that all plants germinate simultaneously and grow to a uniform height. Sets of potatoes and turmeric, if selected with uniformity in the development of eyes while planting, give the same results. Thus there is evidence that the position of the seed in the ground while planting is an important factor in obtaining a uniform crop. Experiments are being continued, and the figures on which the present notes are based will shortly be published.

INDEX TO VOL. XIII

1918.

A

PAGE

ABORTION, CONTAGIOUS, IN MARES AND JOINT-ILL IN FOALS. Etiology and serum treatment of—. J. McFadyean and J. T. Edwards .. 490
Acacia modesta, A HEDGE PLANT 347
ACIDS. Organic—and resistance to disease 19*
ACT. Destructive Insects and Pests—in Mysore 186
ADULTERATION OF AGRICULTURAL PRODUCE 235
AFFORESTATION IN THE UNITED PROVINCES. E. Benskin 685
AGRICULTURAL BANKING. *See* Banking.
,, CALENDAR, 1918, MYSORE (Review) 573
,, DEVELOPMENT. Indian—. 1*
,, EDUCATION 158, 162, 240
,, EXPORTS. The trend of Indian—. A. C. Dobbs .. 249
,, HOLDINGS. Consolidation of—in the United Provinces. H. S. Jevons 222
,, ,, Size and distribution of—in India .. 233
,, IMPLEMENTS. Sale and loan of—. H. R. C. Hailey .. 319
,, IMPROVEMENTS. Bringing of—to the notice of cultivators 238
,, LOANS ACT. Working of—in Burma 75
,, MACHINERY. Scope for—. D. Clouston 325
,, PROBLEMS OF INDIA. Rai Bahadur Ganga Ram. (Review) 367
,, PRODUCE. Increase in—. 239
,, ,, Mixing and adulteration of—. .. 235
,, PROGRESS. Factors in—. 298
,, PROGRESS IN INDIA. A. C. Chatterjee 139

* Page of the Special Science Congress Number of the Journal.

PAGE

AGRICULTURAL PUBLICATIONS. Summarizing and indexing of—. .. 234
,, PUBLICATIONS IN INDIA
(i) From 1st August, 1917, to 31st January, 1918 after 380
(ii) From 1st February to 31st July, 1918 after 764
,, RESEARCH IN INDIA 8*, 583
AGRICULTURE. New books on—and allied subjects 194, 377, 578, 761
AGRICULTURE THROUGHOUT THE WORLD. Ten Years of—. .. 546
AIYAR, A. R. P., and CLOUSTON, D. The physical texture of soils in its relation to crop production 89*
ALLAN, R. G., and TAKLE, J. V. Use of surplus milk in a small dairy: Cheese-making 628
AMERICA. Some observations on agricultural work in—. W. Roberts 272
AMMONIA. By-product—. 510
,, Cost of—. 516
,, Nitric acid from—. 512
Amorphophallus campanulatus 128*
ANANDA RAO, D. Daily variation in the composition of milk .. 82
ANATOMY OF SILKWORM AND MOTH. M. N. De. (Review).. .. 575
Andropogon contortus 743
,, *Sorghum* 127*
ANSTEAD, R. D. Manuring of *Hevea brasiliensis* 660
,, ,, Treatment of fungoid diseases on estates .. 95
ANTHRAX. Prevention of infection by—in manipulation of wool, goat-hair and camel-hair 736
Apis florea 349
,, *indica* 349
ARECA PALM IN MYSORE. Bulletin on Cultivation of—. (Review) .. 572

B

BALING OF SHAFTAL AND LUCERNE HAY FOR ARMY TRANSPORT. A. Howard 717
BAMBOOS. Utilization of—for paper pulp 34*
BANK. Agricultural mortgage—. 78
,, Co-operative—in India 312, 381
,, Land mortgage—. 316
,, State—. 317

* Page of the Special Science Congress Number of the Journal.

PAGE

BANKING. Agricultural—in the delta of Burma. Lawrence Dawson .. 71
„ Development of—and thrift in India. A. C. Chatterjee .. 305
BARBER, C. A. Origin of the Uba cane 544
„ Testing new cane-seedlings in India 243
BEANS. Prussic acid in Burma—. (Review) 741
BEE-KEEPING AT LYALLPUR 348
BEESON, C. F. C. Forest insect conditions in India 114*
BENGAL. Soil types in—. 66*
BENSKIN, E. Afforestation in the United Provinces 685
BERSEEM. Results of—cultivation on some dairy farms 168
BERSEEM SEEDS. Import of—into India by sea 557
BIRDS. Services rendered by—to agriculture 177
BLACK QUARTER 647
BOARD OF AGRICULTURE IN INDIA. Sectional meetings of—. .. 235
„ „ „ Tenth meeting of—. 231
BOOKS ON AGRICULTURE AND ALLIED SUBJECTS. New—. 194, 377, 578, 761
BRADY, M. Motor cultivation. (Correspondence) 759
BRANFORD, R. Common contagious cattle diseases and methods of dealing with them 639
BROOD LAC, *ber* (*Zizyphus jujuba*) 408
„ „ *kusumb* (*Schleichera trijuga*) 408
„ „ *palas* (*Butea frondosa*) 414
BROWN, P. E. Importance of mold action in soils 529
„ W. ROBERTSON. Wheat in the North-West Frontier Province 65
BRUCE, J. An account of some experiments in lucerne cultivation at Saharanpur Remount Depôt 254
BUFFALOES. Two most promising breeds of—in India 170
„ Milch—of the Central Provinces 54
BUNT OF WHEAT 11*
BURMA. Agricultural banking in the delta of—. 71
BUTLER, E. J. Immunity and disease in plants 10*
BUTTER. Ascertaining percentage of water in—. 345

C

Calandra granaria 528
„ *oryzæ* 528
CANALS. Lining of—. 83*

* Page of the Special Science Congress Number of the Journal.

	Page
CATCH-CROPS. Raising of forest trees with cultivation of—. ..	32*
CATTLE. Five most promising breeds of milch—in India	170
,, Milch—of the Central Provinces	54
,, Note on—in the Bombay Presidency. G. F. Keatinge. (Review)	189
CATTLE DISEASES. Methods of dealing with common contagious—.	639
CATTLE-BREEDING. Development of—in India	2
CENTRIFUGAL PUMPS *versus* MHOTES	609
Cephaleuros Mycoidea	13*
Cercospora personata	12*
CHADWICK, D. T. Cotton research	721
CHATTERJEE, A. C. Agricultural progress in India	139
,, ,, Development of banking and thrift in India ..	305
CHEESE-MAKING. The use of surplus milk in a small dairy.. ..	628
CLIMATE. Influence of—on disease resistance	23*
CLOUSTON, D. Co-operative dairy at Telinkheri in its relation to dairying in the Central Provinces	54
,, ,, India's greatest industry : Scope for agricultural machinery	325
CLOUSTON, D., and AIYER, A. R. P. The physical texture of soils in its relation to crop production	89*
COCONUT. Malabar—oil industry	181
COFFEE. Treatment of black rot on an estate	96
COFFEE LEAF DISEASE	12*, 15*
COIMBATORE COLLEGE DAIRY	82
COLEMAN, L. C. Indian agricultural development	1*
Colletotrichum Camelliæ	97
,, *falcatum*	22*
CO-OPERATION. Some recollections and reflections. H. R. Crosthwaite	131
CO-OPERATION IN THE PUNJAB. The spread of—. C. F. Strickland	260, 671
CO-OPERATIVE BANKS. Financing of agriculture and—in Burma ..	77
CO-OPERATIVE BANKS, CENTRAL. The true sphere of—. R. B. Ewbank	381
,, ,, IN INDIA	312
,, DAIRY. *See* Dairy.	
,, GOWLIES' SOCIETIES. Working of—.	58

* Page of the Special Science Congress Number of the Journal.

PAGE

CO-OPERATIVE SOCIETIES. Sale and loan of agricultural implements. H. R. C. Hailey 319
,, SOCIETIES FOR THE SALE OF COTTON. G. F. Keatinge .. 121
,, SOCIETY. A model village—. 178
Corticium Salmonicolor 17*, 100
COTTON. American—. Early trials in Bombay Presidency. J. Mackenna. 397
,, American—in the Punjab 167
,, Co-operative societies for the sale of—. G. F. Keatinge .. 121
,, Determination of the length and uniformity of staple of raw —. Dr. Ball's patent machine 722
,, Egyptian—. 115, 722
,, Experiments in placing of—seeds in different positions while planting 127*
,, Indian—Committee 164
,, Indian—crop 107
,, Kumpta —. 126
,, Methods of selling—in the Southern Maratha Country .. 122
,, Selection in Sea Island—. 279
,, Work of British— growing Association 108
,, World's—shortage. J. A. Todd 110, 287
,, World's—supply 114
,, Yearly output of—in British Empire .. 106, 114
COTTON ADULTERATION REGULATION OF 1829 404
,, BALES IN INDIA. Density of —. J. A. Todd. (Correspondence) 368
,, ,, ,, ,, ,, W. Roberts. (Correspondence) 576
,, CULTIVATION IN CHINA 175
,, CULTIVATION IN THE UNITED STATES 274, 277
,, GROWING RESOURCES OF THE BRITISH EMPIRE. J. Arthur Hutton 105
,, IN ANGLO-EGYPTIAN SUDAN 287
,, IN BRITISH WEST AFRICA 292
,, ON *bhata* 92*
,, PESTS. Control of—in the United States 273
,, PICKING IN THE UNITED STATES 276
,, PLANTS, SEEDS AND UNGINNED COTTON. Prohibition of import into French Colonies of—. 723
,, RESEARCH 174, 721

* Page of the Special Science Congress Number of the Journal.

PAGE

COTTON SEED. Effect on germination of—of passing the *kapas* through the "opener" 719
,, SEED IN INDIA 549
,, ,, OIL INDUSTRY 173
,, ,, SELECTION WORK IN THE UNITED STATES 277
,, STANDARDS IN THE UNITED STATES 273
COW CONFERENCE. Report of the Proceedings of the All-India—. (Review) 744
CREAM TESTING 343
CROP PRODUCTION. Physical texture of soils in its relation to—. .. 89*
CROPS. Factors contributing to increased outturns of—. 3*
,, Peculiar mineral requirements of—. 169
CROSTHWAITE, H. R. Some recollections and reflections 131
Crotalaria juncea 127*, 503
Crotalaria striata 664
CULTIVATION BY MOTOR PLOUGHS 537
,, BY STEAM PLOUGHING TACKLE 539

D

Dacus zonatus 621
DAIRY. Co-operative—at Telinkheri in its relation to dairying in the Central Provinces. D. Clouston 54
,, Use of surplus milk in a small—. 628
DAIRY. BUILDINGS. Ganeshkhind—. 5
,, FARM. Establishment and management of the—. G. K. Kelkar. (Review) 570
,, FARMS. Hints for management of—. 4
,, HERD. Ganeshkhind—. H. E. Lord Willingdon .. 1
,, ,, Willingdon—sale 167
,, TRADE. A Survey of the Madras—. A. Carruth. (Review) .. 568
DAVIS, W. A. Present position and future prospects of the natural indigo industry 32, 206, 441
DAWSON, LAWRENCE. Agricultural banking in the delta of Burma .. 71
DECCAN (BOMBAY) VILLAGE. Land and Labour in a—. A Review. G. F. Keatinge 471
DEER, NOEL. Origin of the Uba cane 727
Diatraea Saccharalis 695

* Page of the Special Science Congress Number of the Journal.

PAGE

DISEASE. Avoidance of—by plants 11*
,, Endurance of—by plants 12*
,, Immunity and—in plants 10*
,, Resistance to—by plants 13*
DISFORESTMENT. Effect of—. 687
DOBBS, A. C. Peculiar mineral requirements of crops 170
,, ,, The trend of Indian agricultural exports 249

E

EDUCATION. Agricultural—. 158, 162, 240
,, Veterinary—. 236
EGYPT. Cotton cultivation in—. 115
EGYPTIAN CLOVER SEEDS. Importation of—into India by sea .. 557
Eichornia crassipes. Manurial value of—. 69*
ENZYMES. Are oxidases—? 62*
EPIZOOTIC LYMPHANGITIS. Compound of mercury in the treatment of—. G. Finzi 480
,, ,, Intrapalpebral test in the diagnosis of—. A. Lanfranchi 479
,, ,, Local reactions in the treatment of—by pyotherapy. H. Velu 483
,, ,, Treatment of—by autopyotherapy. M. Belin 482
Erysiphe graminis 14*
EWBANK, R. B. The true sphere of Central Co-operative Banks .. 381
EXPERIMENTAL ERROR 237

F

FARMING. Electric—and some results 171
FAULKNER, O. T., and ROBERTS, W. Some factors affecting the efficiency in the use of canal water 81*
FERTILIZERS. Legislation for the sale of—. 238
FIBRE, NETTLE. Experiment with—. 522
FIBRES, VEGETABLE 500
FINLOW, R. S. *Rhizoctonia* in jute : The inhibiting effect of potash manuring 65*
FISCHER, C. E. C. Forest grazing and the Nellore "Kancha" system 95*

* Page of the Special Science Congress Number of the Journal.

PAGE

FLAX 504
FLAX SEEDS. Importation of—into British India by sea 557
FOOD. World's—supply 191
FOOD PRODUCTION: CONSIDERABLE INCREASE POSSIBLE 495
FOREST GRAZING AND THE NELLORE "KANCHA" SYSTEM. C. E. C. Fischer 95*
FOREST INSECTS. *See* Insects.
FORESTS. Economic importance of—. 686
,, Physical importance of—. 685
FRUIT GARDEN IN INDIA (in English and Urdu). C. S. Digambari. (Review) 189
FRUIT-TREES. Effect of grass on—.. 88
FUNGI AND DISEASE IN PLANTS: A REVIEW. G. A. Gammie .. 666
FUNGOID DISEASES. Treatment of—on estates. R. D. Anstead. .. 95

G

GAOLAO-AYRSHIRE CROSS 58
,, MONTGOMERY CROSS 58
GANESHKHIND DAIRY HERD. H. E. Lord Willingdon 1
GLANDERS. The intrapalpebral mallein test. A. Lanfranchi .. 479
GRAM. Experiments in placing of—seeds in different positions while planting 128*
GRASS. Effect of—on trees 88
GROUNDNUT. The food-value of—. 351
GROUNDNUT ON *bhata* 91*
GROUNDNUTS. Importance for export 252
GEERLIGS, PRINSEN H. C. Scientific progress in sugar cultivation and manufacture in Java during the last three years 701
GAMMIE, G. A. Fungi and disease in plants: A Review 666
GRASS HERBAGE. Utilization of inferior—. 743

H

HADAPSAR CO-OPERATIVE SOCIETY 178
HÆMORRHAGIC SEPTICÆMIA 647
HAILEY, H. R. C. Sale and loan of agricultural implements .. 319
HEDGE PLANT, *Acacia modesta* 347
HELMINTHIASIS. *Ancylostoma duodenale* as a parasite of *Felis tigris*. Clayton Lane 490

* Page of the Special Science Congress Number of the Journal.

PAGE

HENDERSON, G. S. Results of berseem cultivation on some dairy farms 168
,, Snapshots during a mission to Mesopotamia .. 725
,, Willingdon dairy herd sale 167
Hevea. Influence of spacing on yield 663
Hevea brasiliensis. Manuring of—. 660
HIBISCUS 725
HOLE, R. S. Recent investigations on soil aeration with special reference to forestry 430
HOPE, G. D. Some observations about the soils of the North-East Indian Tea Districts 102*
HORSE. Best—for India 156
HORSE-BREEDING IN INDIA 152
HOWARD, A. Baling of shaftal and lucerne hay for army transport 717
,, Recent investigations on soil aeration with special reference to agriculture 416
,, and HOWARD, G. L. C. Some methods suitable for the study of root development 36*
,, G. L. C. Sun-drying of vegetables 616
HUTTON, C. H. Rainfall, irrigation and the sub-soil water level of the Gangetic plain in the United Provinces 197, 460
,, J. A. Cotton-growing resources of the British Empire .. 105
HYACINTH. Manurial value of water— 69*
,, Water—in the Punjab 549

I

IMMUNITY AND DISEASE IN PLANTS. E. J. Butler 10*
INDIAN AGRICULTURAL DEVELOPMENT. L. C. Coleman 1*
INDIAN AGRICULTURAL EXPORTS. The trend of—. 249
Indian Economic Society. Journal of the —. (Review) 573
INDIAN SCIENCE CONGRESS, 1919 740
INDIGO. Cultivation of—. 210
,, Displacement of natural—by synthetic 37
,, Effects of war on—industry 40
,, Exports of—from India 38
,, Growth of synthetic—industry 33
,, Improvements in agriculture 441

* Page of the Special Science Congress Number of the Journal.

PAGE

INDIGO. Land under—cultivation in India 40
,, Manufacture of—. 213
,, New system of growing Java—. 39*
,, Present position and future prospects of the natural—industry 32, 206, 441
,, Principal world's markets for natural and synthetic—. ... 42
,, *Psylla* on—. 447
,, Wilt on—. 447
INDIGO CESS ACT 555
,, CESS IN TRAVANCORE 556
,, ON *bhata* 91*
,, SOILS. Deterioration of—. 452
INFECTION 14*
INSECT. Forest—conditions in India. C. F. C. Beeson 114*
INSECT PESTS. Forest—of British India 119*
,, ,, Forest—of Canada 118*
,, ,, Forest—of Central Europe 115*
,, ,, Forest—of the United States 116*
INSECTS. Attraction of—for chemical substances 621
INSECT PHYSIOLOGY. Beginnings in—and their economic significance. S. K. Sen 620
IRRIGATION. Efficiency of—methods in the Punjab 81*
,, Sources of loss of water in—. 83*
IRRIGATION BY CENTRIFUGAL PUMPS 609
,, BY MHOTES 609
,, IN SIND 653
,, IN THE UNITED PROVINCES 197
,, INVESTIGATIONS IN THE UNITED STATES 280

J

JAVA. Scientific progress in sugar cultivation and manufacture in—during the last three years 701
JEVONS, H. S. Consolidation of agricultural holdings in the United Provinces 222
JOGENDRA SINGH, SIRDAR. Experiments in steam-ploughing .. 47
JOHNE'S DISEASE. A. L. Sheather 23
JOINT-ILL IN FOALS 490

* Page of the Special Science Congress Number of the Journal.

PAGE

JORDAN, A. E. Problem of sugar manufacture in India. (Correspondence) 369, 747
Journal of the Indian Economic Society. (Review) 573
Jowar. Experiments in placing of—seeds in different positions while planting 127*
Jowar ON *bhata* 92*
JUTE. Extension of—production 501
,, *Rhizoctonia* in—. The inhibiting effect of potash manuring .. 65*
JUTE SUBSTITUTES 502

K

KANCHA SYSTEM OF GRAZING 95*
KAPOK FLOSS 504
KEATINGE, G. F. Co-operative societies for the sale of cotton in the Southern Maratha Country 121
,, ,, Factors in agricultural progress 298
,, ,, Land and Labour in a Deccan village : A Review .. 471
KULKARNI, M. L. Experiments in planting sugarcane sets with a single eye-bud and pot experiments with other seeds placed in different positions while planting 125*
KHARAK SINGH, BHAI. Effect on germination of cotton seed of passing the *kapas* through the "opener" 719

L

LAC CULTIVATION. Present condition of—in the plains of India. C. S. Misra 405
LAND AND LABOUR IN A DECCAN VILLAGE : A REVIEW. G. F. Keatinge 471
LAND IMPROVEMENT ACT. Working of—in Burma 77
LAND MORTGAGE BANKS 316
Lepidiota albohirta 147
LUCERNE. An account of some experiments in—cultivation at Saharanpur Remount Depôt. J. Bruce 254
,, Baling of—hay 717
LEAKE, H. M. Organization of agricultural research in India .. 583

M

MACKENNA, J. The early history of cotton in Bombay 389
MCLAREN, J. Notes on motor cultivation 537

* Page of the Special Science Congress Number of the Journal.

PAGE

MADRAS DAIRY TRADE. A survey of the—. A. Carruth. (Review) .. 568
MAIN, T. F. Irrigation in Sind 653
MAIZE SMUT 18*
MANGO. All about the—. V. R. Gadgil. (Review) 367
MANURE. Experiments with night-soil—. P. C. Patil 281
MANURES. Development of Indian agriculture and use of—. .. 5*
MANURING AND PLANT DISEASES 24*
„ OF *Hevea brasiliensis*. R. D. Anstead 660
MARSDEN, E. The economic aspect of Indian silviculture .. 29*
MASON, C. W. In Memoriam 365
MESOPOTAMIA. SNAPSHOTS TAKEN DURING A MISSION TO—. .. 725
MHOTES *versus* CENTRIFUGAL PUMPS 609
MILCH BUFFALOES. *See* Buffaloes.
MILCH CATTLE. *See* Cattle.
MILK. Daily variation in the composition of—. 82
„ Use of surplus—in a small dairy 628
„ Yield and quality of—in the Central Provinces 55
MILK SUPPLY IN INDIA AND METHODS OF IMPROVEMENT 744
„ SUPPLY IN THE CENTRAL PROVINCES 55
„ TESTING 333
MINERAL REQUIREMENTS OF CROPS. Peculiar—. 169
MISRA, C. S. The present condition of lac cultivation in the plains of India 405
MOLDS. The importance of their action in soils. P. E. Brown .. 529
MOSQUITOS. Physiology of—. 622
MOTOR PLOUGHS 537, 542
MOTOR TRACTORS. Utility for tillage purposes 710
MYSORE. Cultivation of Areca Palm in—. (Review) 572
MYSORE AGRICULTURAL CALENDAR 1918. (Review) 573

N

NATALITE. Manufacture of—in South Africa 729
NATURE STUDY AND SIMPLE AGRICULTURAL TEACHING FOR THE PRIMARY SCHOOLS OF BURMA. A hand-book of—. E. Thompstone. (Review) 565
NELLORE GRAZING SYSTEM 95*
NIDHIS 313

* Page of the Special Science Congress Number of the Journal.

PAGE

NIGHT-SOIL. Experiments with—as manure 281
NITRATE POSITION 356
NITRIC ACID. Cost of—. 516
NITRIC ACID FROM AMMONIA 512
NITROGEN FIXATION 505
„ „ Arc process 506
„ „ Cyanamide process 509
„ „ Cyanide process 512
„ „ General Chemical Company process 518
„ „ Haber process 508
NUTRITION. Influence of—on disease resistance 23*

O

OIL-SEEDS 192, 252
OIL ENGINE. Best—on market 614
OIL ENGINE AND ITS APPLICATION TO INDIAN AGRICULTURE. W. M. Schutte 608
ORGANIZATION OF AGRICULTURAL RESEARCH IN INDIA. H. M. Leake .. 583
OSBORNE, R. A few simple tests for use of dairy farmers, dairymen and students 333
OXIDASES: WITH SPECIAL REFERENCE TO THEIR PRESENCE AND FUNCTION IN THE SUGARCANE. Ramji Narain 47*

P

PATIL, P. C. Experiments with night-soil as manure 281
PEARSON, R. S. Timber supplies in India 40*
PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC. 183, 363, 558, 737
PEST GANGS. Organization of—. 102
PHOSPHATE. German—"substitutes" 731
PHOSPHATIC MANURES. Their value in India and manufacture on a larger scale 237
Phytophthora 22*, 100, 102
PICKERING, SPENCER. Effect of one plant on another 86
PINK BOLL-WORM 724
PLANT AND SEED IMPORTS. Regulation of—into British India . .. 359
PLANT DISINFECTION. Rules for—at Calcutta 556
PLANT IMPORTS BY POST. Regulation of—. 557

* Page of the Special Science Congress Number of the Journal.

PAGE

PLANT TYPES FOR COLLEGE STUDENTS. Father Ethelbert Blatter. (Review) 366
PLANT-BREEDING. Development of Indian agriculture and—work .. 5*
PLANTS. Immunity and disease in—. 10*
PLOUGHING. Cost of steam—. 53
„ Experiments in steam—. Sirdar Jogendra Singh .. 47
POT CULTURE. An improved form of—. 37*
POTASH MANURING. *Rhizoctonia* in jute : Inhibiting effect of—. .. 65*
POTATO BLIGHT. 11*
„ STARCH. Manufacture of—in Norway 735
PRUSSIC ACID IN BURMA BEANS. (Review) 741
PUNJAB. American cotton in the—. 167
„ Wheat variety trials in the—. 10
Pycnosoma flaviceps 625

R

RAMJI NARAIN. Oxidases : With special reference to their presence and function in the sugarcane 47*
RATIONS BALANCED FROM RESTRICTED SOURCES. Physiological effect on growth and reproduction of—. 358
RAVINE RECLAMATION IN THE UNITED PROVINCES 690
RESEARCH. Departmentalization of—in India.. 602
„ Agricultural—in India 8*
Rhizoctonia in jute : The inhibiting effect of potash manuring. R. S. Finlow 65*
RINDERPEST. Experiments on the treatment of—with various drugs.. 484
RINDERPEST AT HISSAR 639
ROBERTS, W. American cotton in the Punjab 167
„ „ Density of Indian cotton bales (Correspondence) .. 576
„ „ Some observations on agricultural work in America .. 272
„ „ Wheat variety trials in the Punjab 10
„ „ and FAULKNER, O. T. Some factors affecting the efficiency in the use of canal water 81*
ROOT-DEVELOPMENT. Some methods suitable for the study of—. A. Howard and G. L. C. Howard 36*
ROSENFELD, ARTHUR H. Selecting sugarcane before planting : Some demonstrative experiments 695

* Page of the Special Science Congress Number of the Journal.

PAGE

RUBBER. Methods of treatment of—canker 99
,, "Natural" or spontaneous coagulation of latex in the production of—. 734
,, New use for sugar in curing of—. 731
,, Pink disease of—. 100
,, *Phytophthora* on—. 96, 100
RURAL BIAS. An experiment in—in a Secondary school 162
,, SCIENCE, INCLUDING SCHOOL-GARDENING. R. N. Sheridan .. 158

S

Sal SEEDLINGS. Growth as influenced by soil-aeration 430
SANDALWOOD. Spike disease in—. 552
SANN. Experiments in placing of—seeds in different positions while planting 127*
SANN-HEMP 503
SAYER, WYNNE. Sugar manufacture in India. (Correspondence) 374, 754
SCHOOL. An experiment in rural bias in a secondary—. 162
SCHOOL-GARDENING. Rural science, including—. 158
SCHUTTE, W. M. Oil engine and its application to Indian agriculture .. 608
SEED FOR SOWING OF IMPROVED VARIETIES. Facilities for transport by rail 725
SEN, S. K. Beginnings in insect physiology and their economic significance 620
SHAFTAL. Baling of—hay 717
SHEATHER, A. L. Johne's disease 23
SHERIDAN, R. N. Rural science, including school-gardening .. 158
Shorea robusta 430
SILK CULTURE IN INDIA 553
SILKWORM AND MOTH. Anatomy of—. M. N. De. (Review) .. 575
SILVICULTURE. The economic aspect of Indian—. E. Marsden .. 29*
SMITH, W. Handling young stock. (Correspondence) 576
SOIL. *Bhata*—. 89*
,, *Dorsa*—. 90*
,, Effect of—texture on growth 418
,, Influence of—on disease resistance 23*
,, Its structure 421
SOIL-AERATION 37*, 93*

* Page of the Special Science Congress Number of the Journal.

PAGE

SOIL-AERATION. Effect of—on distribution of plants 429
„ „ Effect of—on quality of crop produced 427
„ „ Influence of—on growth of plants 417
SOIL-AERATION IN AGRICULTURE. Recent investigations on—. A. Howard 416
„ „ „ FORESTRY. Recent investigations on—. R. S. Hole 430
SOIL-DRAINAGE 93*
SOIL GASES. 423
„ „ Influence of—on development of soil roots 435
SOIL-VENTILATION. Importance of—. 148
SOILS. Importance of mold action in—. P. E. Brown 529
„ Physical texture of—in its relation to crop production .. 89*
„ Some observations about the—of the N.-E. Indian tea districts 102*
Sphacelotheca Sorghi 11*
SPIKE DISEASE IN SANDALWOOD 552
„ „ „ „ A conference on—in Mysore .. 186
SPRAYING. Co-operative—of tea gardens 76*
SPRAYING FLUIDS FOR TEA GARDENS 79*
SPRAYING MACHINERY 76*
STEAM-PLOUGHING TACKLE 539, 542
STEAM-PLOUGHING. *See* Ploughing.
Stegomyia scutellaris 625
STOCK. Handling young —. Wm. Smith (Correspondence) .. 576
„ „ „ —. R. C. Wood (Correspondence) .. 368
STRICKLAND, C. F. The spread of co-operation in the Punjab 260, 671
SUDAN. Cotton in Anglo-Egyptian—. 287
SUGAR. Influence of—content on disease resistance 22*
„ New use for—in curing of rubber 731
„ New process for recovery of sucrose from final molasses in Hawaii 728
„ Scientific progress in cultivation and manufacture of—in Java during the last three years. H. C. Prinsen Geerligs 701
„ The high price of—and how to reduce it. Harold Hamel Smith. (Review) 566
SUGAR MANUFACTURE IN INDIA. A. E. Jordan (Correspondence) 369, 747
„ „ „ „ Wynne Sayer (Correspondence) 374, 754
SUGAR-BEET. Intercultivation of wheat and—. 70

* Page of the Special Science Congress Number of the Journal.

PAGE

SUGARCANE. A new disease of—in Porto Rico 355
,, Action of copper arsenate and arsenious acid on—roots 145
,, Experiments in planting—sets with a single eye-bud .. 125*
,, Oxidases: With special reference to their presence and function in the—. 47*
,, Prospects of—cultivation in Punjab canal colonies .. 52
,, Selecting—before planting: Some demonstrative experiments. Arthur H. Rosenfeld 695
SUGARCANE BY-PRODUCTS 729
,, IN JAVA. Influence of weather on the crop 701
,, INDUSTRY IN INDIA 239
,, ON *bhata* 93*
,, SEEDLINGS. Testing—in North India 243
,, , UBA. Origin of the—. 544, 727
SUPERPHOSPHATE. Effect of—on various crops in Bihar soils .. 453

T

Tachardia lacca 405
TAKLE, J. V., and ALLAN, R. G. Use of surplus milk in a small dairy: Cheese-making 628
TANNIN. Influence of—on disease resistance 19*
TEA. Mosquito blight on—. 102
,, Red rust of—. 13*
,, Soils of North-East Indian—districts 102*
,, Spraying of -in North-East India. A. C. Tunstall .. . 73*
,, Treatment of root-disease of young—. 95
,, ,, of brown blight on—. 97
THOMPSON, W. P. Bee-keeping 348
THOMPSTONE, E. *Acacia modesta*, a hedge plant 347
Tikka DISEASE OF GROUNDNUT 12*
TIMBER SUPPLIES IN INDIA. R. S. Pearson 40*
TODD, J. A. Density of Indian cotton bales. (Correspondence) .. 368
,, ,, World's cotton shortage 110, 287
TOXIN. Formation of—in soil by a growing plant 89
TRACTORS. *See* Motor tractors.
TREE WOUNDS. Effect of light on healing of—. 734
Trifolium resupinatum 254, 717

* Page of the Special Science Congress Number of the Journal.

PAGE

TUBERCULOSIS. Note on the prevalence of bovine—in the Punjab. G. Taylor 488
" Susceptibility of Indian milch cattle to—. W. Glen Liston and M. B. Soparkar 485
TUNSTALL, A. C. The spraying of tea in North-East India .. 73*

U

UBA CANE. Origin of the—. 544, 727
UNITED PROVINCES. Afforestation in—. 685
" " Consolidation of agricultural holdings in—. .. 222
" " Rainfall, irrigation and the sub-soil water level of the Gangetic plain in—. C. H. Hutton. 197, 460
Urtica Diocia 522
Ustilago Zeæ 18*

V

VEGETABLES. Sun-drying of—. G. L. C. Howard 616
VETERINARY DEPARTMENTS IN INDIA 1916-17. Statistics of the Provincial Civil—. 551
VETERINARY EDUCATION 236
VETERINARY RESERACH : SOME RECENT CONTRIBUTIONS 479

W

WHEAT. Bunt of—. 11*
" Cpr. No. 13—in North-West Frontier Province 70
" Farrer's Federation—in North-West Frontier Province .. 65
" Inter-cultivation of—and sugarbeet 70
" Irrigation and cultivation of—in Sind 657
" Protection of—from weevils 527
" Pusa—in North-West Frontier Province 65
" Variety trials of—in the Punjab. W. Roberts .. 10
" Watering of—in the Punjab 16
WHEAT MILDEW 14*
" STORAGE. Experiments in Australia 726
WHEATS. Punjab—*versus* Pusa—. 15
WHEATS, HARD. Resistance of—to parasites 21*

* Page of the Special Science Congress Number of the Journal.

PAGE

WAR. Effect on Indian agriculture 250
WATER HYACINTH. Manurial value of—. 69*
,, HYACINTH IN THE PUNJAB 519
,, REQUIREMENTS OF CROPS 210
,, SAVING IN IRRIGATION 85*
,, SAVING EXPERIMENTS IN SIND 656
WEEVILS. Protection of wheat from—. 527
WILLINGDON, H. E. LORD. The Ganeshkhind dairy herd 1
WILT OF *Cajanus indicus* 24*
WOOD, R. CECIL. Handling the young stock (Correspondence) .. 368
WOODHOUSE, E. J. In Memoriam 242

Z

ZEMINDAR HITKARI OR THE ZEMINDAR'S FRIEND. (Review) .. 712

* Page of the Special Science Congress Number of the Journal